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FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

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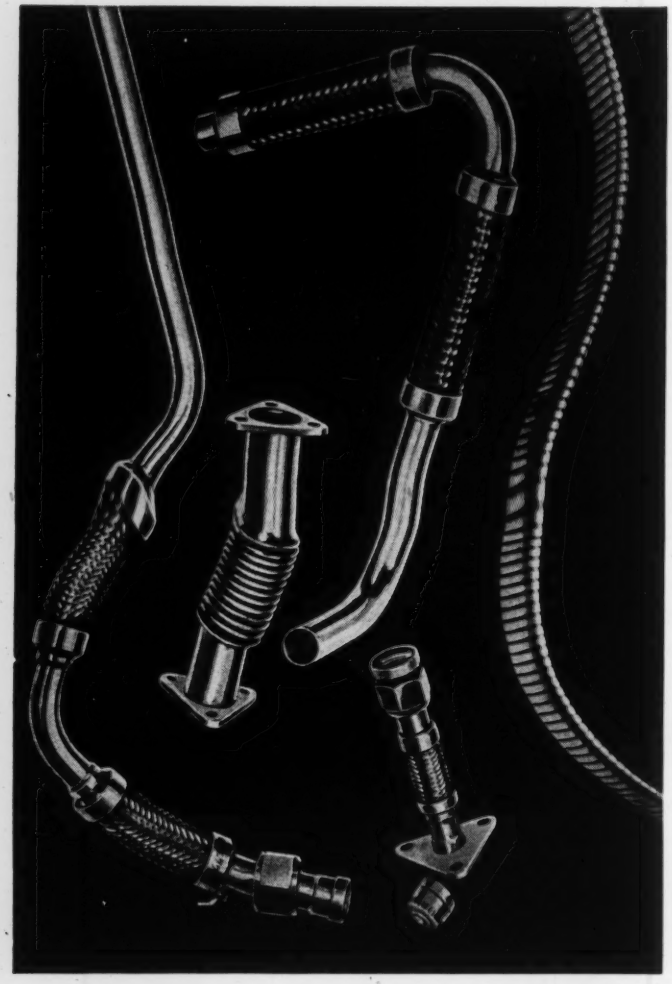

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Engineering News Roundup

Lead Time Key Factor In Defense Plans

Adm. Rickover Compares U. S. Technology with Russia's

WASHINGTON, D. C.—"Lead time . . . is the factor which more than any other is likely to win the next war for the nation which succeeds in reducing it significantly below that of its competitor."

This was emphasized recently by Rear Admiral H. G. Rickover, proponent and builder of the Navy's atom-powered submarines, speaking at a meeting of the Society of Business Magazine Editors. He defined lead time as "the time which elapses between conception of a new idea, its development, and finally its fruition in the completed new article rolling from the production lines.

"Some things we presently assume" Adm. Rickover said "must be re-examined even if they are unpleasant. None of us can afford, for our own or for the national interest, to wrap ourselves too tightly around our present assumptions and habits."

One assumption often made "is that our superior inventive genius will guarantee us a good technological margin over an enemy." This assumption is dangerous. It is compounded by the comfortable belief that whatever anyone else can do, we can do better.

Citing recent progress in Russia, Adm. Rickover said that a comparison of mathematics textbooks shows that in some of the most advanced areas the Russian efforts are on a par with the best work done in the West. The Russians are excellent, he added, in the use of large-scale electronic computers. One such device observed recently by an American is a type unknown in the United States.

Machine Design editor Colin Carmichael (left) and Adm. H. G. Rickover at the meeting of the Society of Business Magazine Editors

"The Russians," Rickover observed "are very attentive to fundamental research—to research for its own sake, without any special reference to a particular problem.

"You have read what kind of job the Russians have done on jet engines, on radar, on long-range weapons, and on atomic weapons. . . Any competent United States aeronautical engineer who examines published photographs of modern Soviet aircraft can readily deduce that they are doing absolutely first-class work in the aeronautical sciences.

"The Russians apply the best capitalist incentives to top people to get them to do a good job—and to this they add . . . individual responsibility for failure.

"In addition to their own abilities, the Russians are expert at exploiting the knowledge of others. Our atomic scientists learned at Geneva last summer that the Russians have great respect for American technical literature. They know well the technical publications of the Western nations, and they make special efforts to publish the best articles rapidly and to disperse them widely.

"Our people also learned that in certain areas important to the Russians, such as electric power and key military technology, they permit considerable latitude to the man in charge. Nor are the top people in research and development penalized quite as promptly or as harshly for failures as are top men in other work. Someone seems to have put across the idea that chances must be taken in these fields, though it is true that a top man will not stay on top very long if he is wrong too many times."

Commenting on Russian accom-

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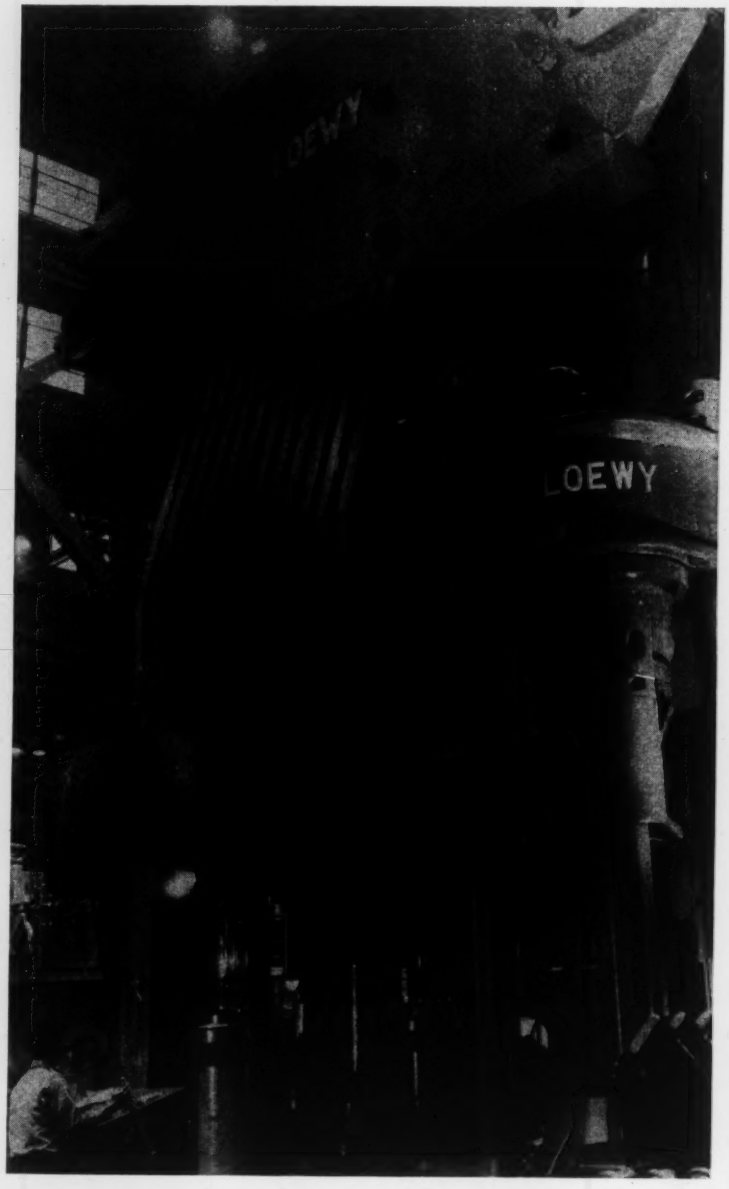

BIGGEST PRESS in the U. S. Air Force heavy press program is now in operation at Wyman-Gordon plant, North Grafton, Mass. It stands 50 ft above operating floor level and extends 60 ft below. Total weight is 10,750 tons, of which 7500 tons are moving parts. The press is capable of 106 million lb pressure

plishments with low lead times, Rickover observed that the world's most powerful nuclear particle accelerator has been in operation in Russia for two years. He said, also, that three engineers from major American corporations reported that a large ball-bearing plant they toured in Moscow was a model of automation. On another occasion, former U. S. Senator Benton returned from a tour of Russia with the statement that their rate of industrial production is increasing 6% a year, in contrast to 3% in this country.

"The Russians have also undertaken a vast educational program to train their people. It began a long time ago and it is now being accelerated."

In contrast, Rickover referred to deficiencies in American schools observed by Lewis L. Strauss, Chairman of the Atomic Energy Commission.

"Sooner or later" Rickover said "all theoretical knowledge becomes universal. It follows that what counts today is not so much inventive genius as the practical ability to translate inventions into items rolling off the production line. This is a field in which Americans have always shown particular aptitude. We have it still, . . . but we have not fully applied this aptitude to the cutting of lead time on important items. Lead time has always been a key factor in warfare."

Automatic Transmissions Now Made For Highway Trucks

INDIANAPOLIS, IND.—The first automatic transmission to be designed specifically for highway trucks is now in production at the Allison Div. of General Motors. Designated CTP-4 Powermatic, the new transmission is scheduled for service in a forthcoming line of Chevrolet trucks.

The Powermatic is an extension for highway use of the Allison Torqmatic Drive now used in heavy-duty, off-highway equipment produced for military and industrial use. It is a torque-converter type, power-shifting transmission with six speeds forward and one reverse, plus an integral hydraulic retarder for braking action. The retarder relieves the service brakes from long downhill duty and provides the operator with a braking force approximately six times greater than that by engine braking.

Special Projects Engineering Division within the Engineering Branch of the Lockheed Aircraft Georgia Div. at Marietta was announced recently. Projects cur-

Front Cover

Today, joining and fastening methods for plastics are fully as versatile as those for metals. Our front cover by George Farnsworth highlights a few methods; R. E. Wallenbrock's article in this issue (see Contents page) outlines many more.

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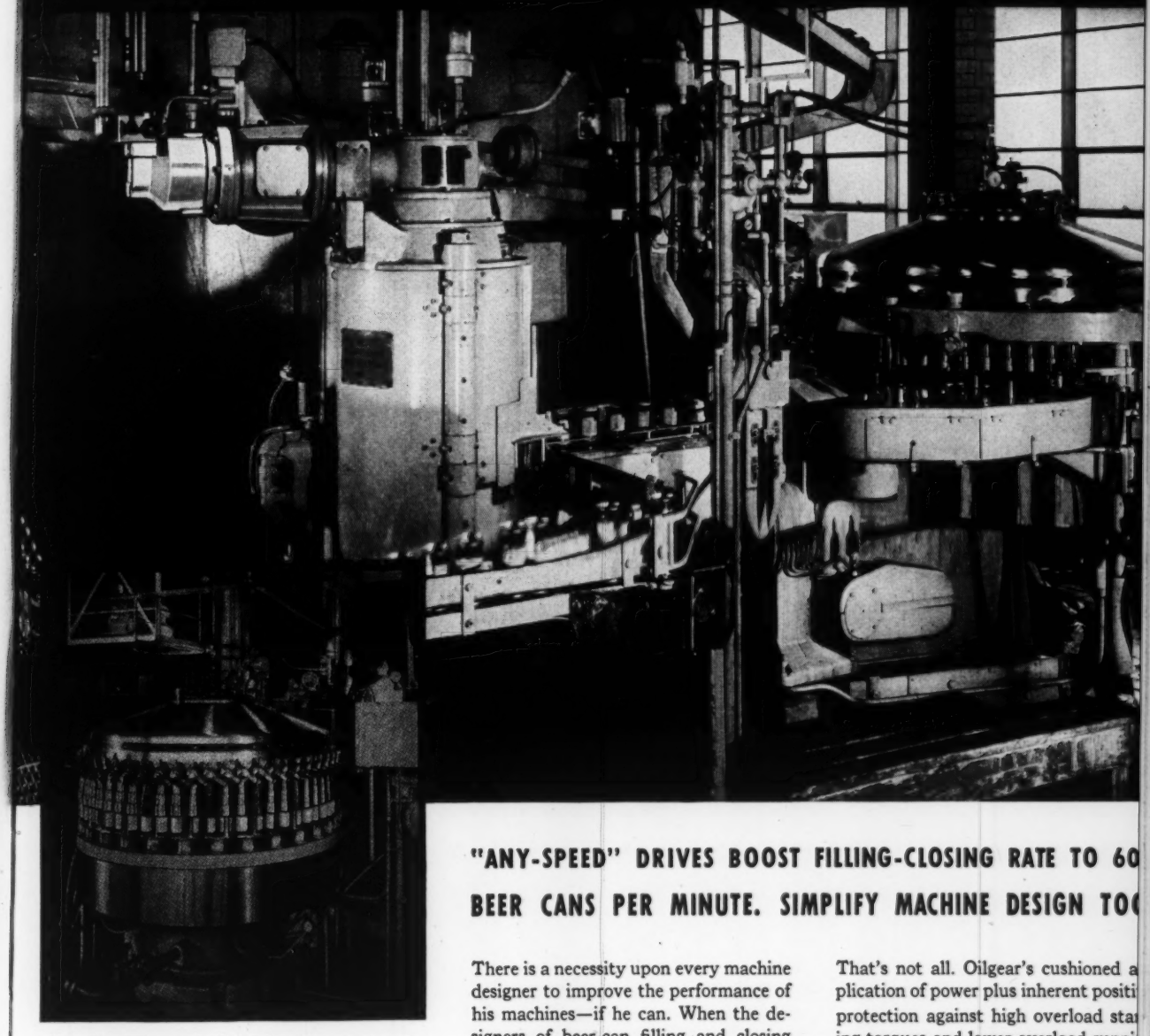
You too can discover
THE WAY UP IS OILGEAR



Beer Can Filling and Closing Machines equipped with Oilgear "ANY-SPEED" Drives are operating in many breweries. With Oilgear, beer can filling and closing production climbed from 360 to 600 cans a minute.

OILGEAR
Fluid Power

PIONEERS...NOW THREE PLANTS FOR FLUID POWER

PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS & VALVES

"ANY-SPEED" DRIVES BOOST FILLING-CLOSING RATE TO 60 BEER CANS PER MINUTE. SIMPLIFY MACHINE DESIGN TO

There is a necessity upon every machine designer to improve the performance of his machines—if he can. When the designers of beer-can filling and closing machines raised the rate from 150 to 360 cans per minute, the drive limit seemed to be reached. Yet, their users wanted more production *without spillage* or can conveyor problems.

Then these engineers tried Oilgear "ANY-SPEED" Drives . . . the Fluid Power and Control that gave them what they wanted and—even more.

These engineers stipulated: • accelerate machines to half speed in 2 seconds • accelerate machines to full speed in 5 seconds • decelerate and stop machines in 4/10 seconds • a filling-closing rate of 425 cans per minute.

The Oilgear drive accelerated and decelerated so smoothly, it actually provided: • acceleration to full speed in 2 seconds • deceleration and stop in 2/10 seconds • a filling-closing rate of 600 cans per minute.

That's not all. Oilgear's cushioned a plication of power plus inherent positi protection against high overload sta ing torques and lower overload runni torques eliminated the need of mecha ical slip clutches. Thus, the machine d sign is simplified and maintenance negligible.

This smooth yet swift acceleration a deceleration that allows brewers to ha dle full cans without spilling is one two tremendously important Oilge advantages. Utterly variable, flexi and controllable speed is the other. The and other superiorities are writing n history in machine design. *You oug to know the details of that histo* Why don't you contact a nearby Oilge engineer, or write to Milwaukee. I cost, but the profits may be great.

THE OILGEAR COMPANY
1568 W. Pierce Street
Milwaukee 4, Wisconsin

PACKARD "PREDICTOR," developed to gage public acceptance of car innovations, is said the ultimate to date in a retractable hardtop. Roof doors of connected aluminum extrusions, sliding in nylon channels, open automatically like a roll-top desk when side doors are opened or independently under button control. Flat glass backlight at reverse angle also retracts under power. Shaded windshield is shaped to permit easy view of traffic lights. Built on a 122-in. wheelbase, the Predictor has a 310-hp engine, and an overall height of 54⅛ in.

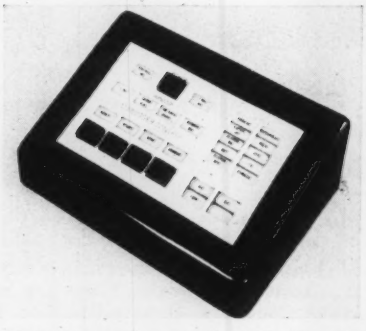
rently assigned to the new division include experimental design development of an advanced landing gear for future assault and cargo aircraft, research and development of aircraft refueling systems, and design of operational aids for the C-130 Hercules prop-jet transport.

Data Processor Prints And Wires Aluminum Tags

LOS ANGELES, CALIF.—A new high-speed electronic data-processing machine which automatically sets type and embosses metal plates has been announced by Dashew Business Machines Inc. The machine can perform four auxiliary operations at the same time.

Known as Databosser V100-EW, this newest of word and phrase printers adaptable to integrated data processing uses punched cards, punched tapes or magnetic tapes.

In addition to its basic functions, the Databosser can tie wires to



Main control panel for Databosser, new electronic equipment to produce 1000 different metal identification or writing plates per hour

plates, emboss sequence numbers, coat embossed characters for easier reading and notch plates for coding or sorting. The wiring unit is said to be the first completely automatic machine to replace wiring of metal tags by hand.

When cycled for repetitive production, the equipment delivers up to 6000 completed plates per hour. Its manufacturers consider it particularly useful in advanced sys-

Topics

Map-vending machine installed in the Geneva, Switzerland, railway station provides a map showing the traveler how to reach the street for which he is searching.

• • •

Flying Low: Autos traveling over 60 mph are actually flying low, say Dayton Rubber Co. engineers. Centrifugal force developed in the tires at those speeds lifts them off the road, reducing road gripping area.

• • •

Another new sports car has been announced by De Soto. Featuring a 315-hp engine, the two-door model will be called the "Adventurer." You can get it in your choice of two-tone combinations, just so one of the tones is gold and the other is either black or white.

• • •

Changeable paint for autos has been announced by Du Pont. Its metallic ingredients seem to make it change color as the auto speeds past. Not content with the 200 or more color combinations presently available, auto makers are designing them to change in midstream. Imagine the confusion on the local police radio in describing the getaway car.

• • •

Russian engineering graduates represent 31 per cent of the higher education graduates in the U.S.S.R., reports the National Science Foundation. This compares to only 8 per cent in the U. S. However the ratio of graduate professionals to total population in Russia is only 80 in 10,000 compared to 320 in 10,000 in the U. S.

• • •

Jet-engine noise is still a question for debate. An expert at a recent CAA symposium said the problem still hasn't been licked. Other problems facing jet airliner users include runway length and runway strength. A safe runway length is estimated to be about 11,000 ft. No U. S. airport has a runway this long; closest is in Honolulu.

• • •

The "furlong stone" is being replaced by the meter in India. Metric units are being officially adopted as a step toward standardization in that country.

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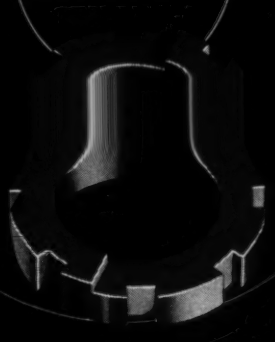
Not 25 not 50 not 75 **but 100%**



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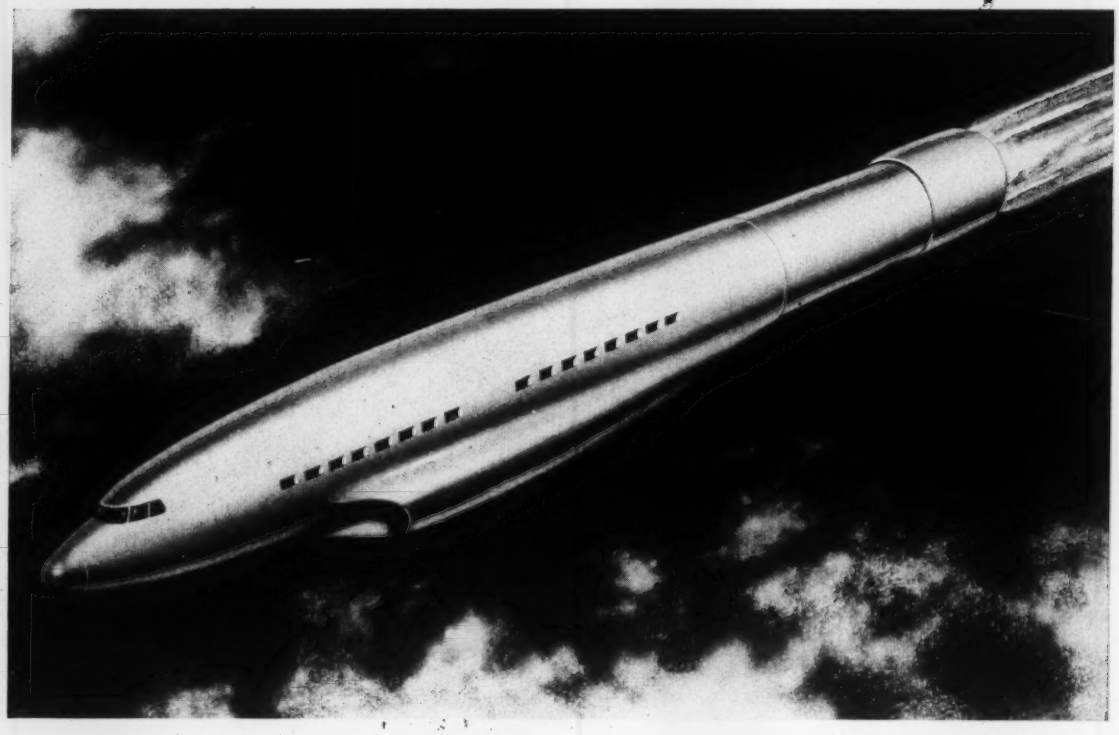
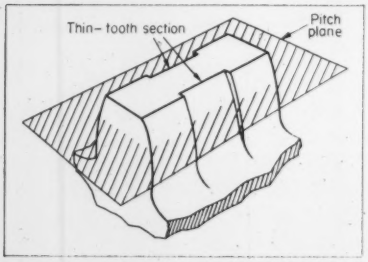


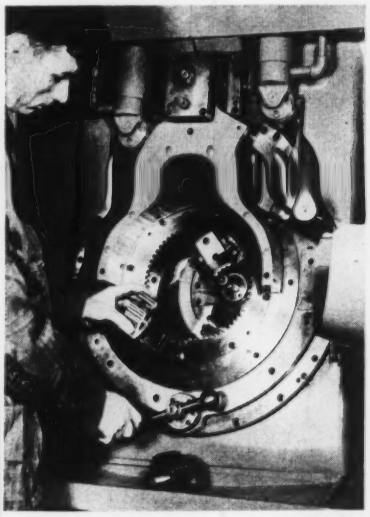
NO WINGS AT ALL are the conspicuous feature of this aircraft-of-the-future recently disclosed at Collins Radio Co., Cedar Rapids, Iowa. Called Aerodyne, the craft was designed by Dr. A. M. Lippisch who also pioneered the delta wing for airplanes and developed the World War II German Messerschmitt 163. Dr. Lippisch says Aerodyne will rise and descend vertically and will operate at speeds from zero to supersonic. Jet exhaust produces forward thrust and deflected airstream provides control. Flying scale models of Aerodyne have been prepared under Navy contract

tems to control and facilitate production, storage, shipping and receiving. It could provide systematic identification of parts in process, raw materials and finished products.

Shaving Process Makes Thin-Tooth Gear Sections

DETROIT, MICH.—A new high-speed process that produces uniform, accurate, thin tooth sections in the flanks of spur gear teeth by a patented planetary shaving method has been developed by National Broach & Machine Co. Thin tooth sections of this type avoid the tendency of transmissions to slip out of gear.





A variety of shapes can be produced by the new machine. Thin tooth sections can be specified in either one or both sides of all of the teeth of a spur gear. The profile of the section closely approximates an involute form and is usually well within required profile tolerances.

Awards For Engineering Ideas Announced

Cash prizes have been announced recently for ideas and suggestions to use certain engineering materials and processes more effectively.

The James F. Lincoln Arc Welding Foundation, Cleveland 17, O., has invited ideas on any aspect of arc welding that can be used to advance welded design, welding engineering or the general application of the arc welding process. No restrictions are placed on either the nature or the extent of

First it was LED-LOK...now to supplement Led-Lok here's a brand new locking fastener that...

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featuring the heat-proof Expansion Insert

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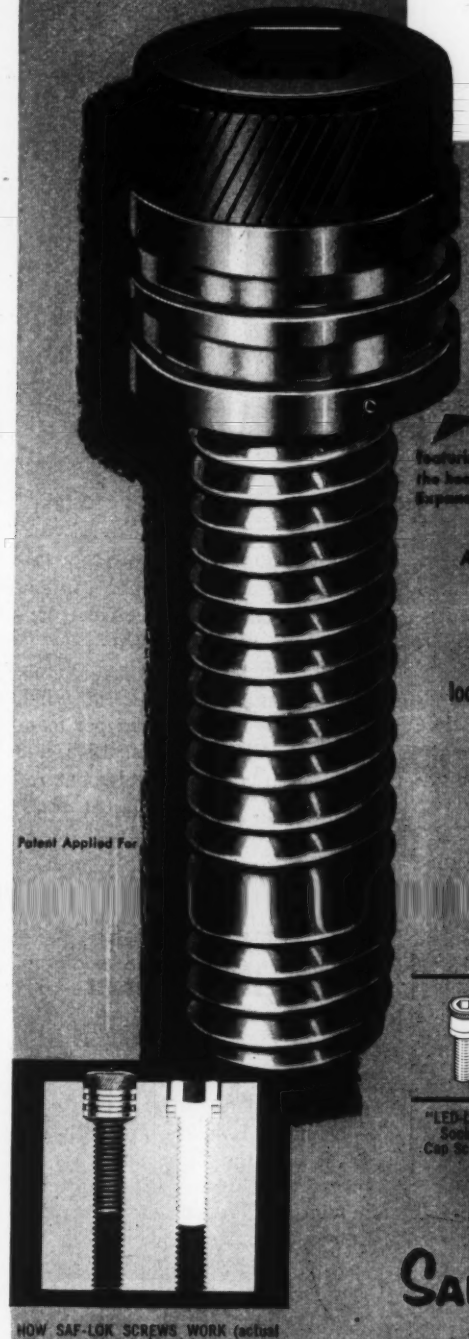
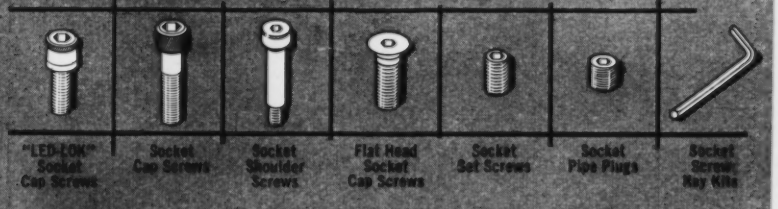


Patent Applied For

HOW SAF-LOK SCREWS WORK (actual cutaway photo): SAF-LOK Screw is pre-assembled. After drawing hand-tight, the wrench is used, causing the expansion insert to spread and keep the screw permanently tight. Insert is bronze, will never score the screw cavity.

BLUE-DEVIL SAF-LOK SOCKET SCREWS will never vibrate or shake loose when drawn up tight. They make an absolute seal against oil, water, gas and air . . . form an effective locking device for use in oversize counterbores. The SAF-LOK Insert is bronze, not affected by heat and safe for use with food equipment.

Wide range of SAF-LOK styles and sizes.



Socket Screws Exclusively!

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WRITE TODAY for sample SAF-LOK Socket Screws. No obligation!

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ideas submitted. A total of $20,000 will be distributed in 20 awards, the first of which is $5000. Entries must be submitted to Dr. E. E. Dreese, Foundation chairman, before July 30, 1956.

American Silver Co. will award a total of $1000 in 31 separate cash prizes, the first of which is $350. Entries must describe new uses for stainless-steel strip that can be rolled down to thicknesses as low as 0.0005-in. and to tolerances as close as 0.0001-in. Information and entry blanks may be obtained from Chairman, Prize Awards Committee, American Silver Co., Flushing 54, N. Y. The contest closes midnight, May 30, 1956, and winners will be announced not later than June 30, 1956.

CALFDOZER is this pint-size earth-mover produced by the British firm Aveling-Barford Ltd. for small jobs or tight quarters. Already proved an aid in home construction, Calfdozer has operated successfully in ship's holds shifting bulk cargo driving unloading

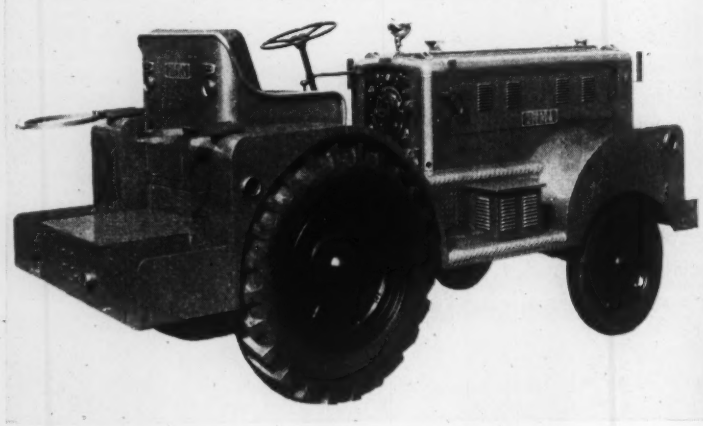
Power Council Sees More Electricity Used

SCHENECTADY, N. Y. — By 1965, each U. S. worker will use as much electricity every working hour as it takes to light 1000 one-family homes for the same period. This was predicted recently by the General Electric Co. "More Power to America" Council which indicated these other industry goals for 1965:

A 33 per cent increase in worker output; a 50 per cent increase in the annual rate of expenditures for plant and equipment (from $30 million in 1955 to $45 million in 1965); a 110 per cent increase in community electrification, and a 117 per cent increase in farm electrification.

The predictions are based on anticipated population growth, a rising standard of living and the historical doubling of electrical consumption every 10 years.

The council reported that industrial consumption of electricity had increased from 4.74 kwhr per man-hour in 1945 to 9.7 in 1955 and that new plant and equipment expenditures from 1950 to 1955 amounted to $134.4 billion.



SELF-PROPELLED welding unit announced recently by Hobart Brothers Co., Troy, O., has generator coupled directly to engine. Designed primarily as handy and mobile sources of power for welding, the 400-amp and 600-amp models can tow other equipment to the job and function as auxiliary electric generators

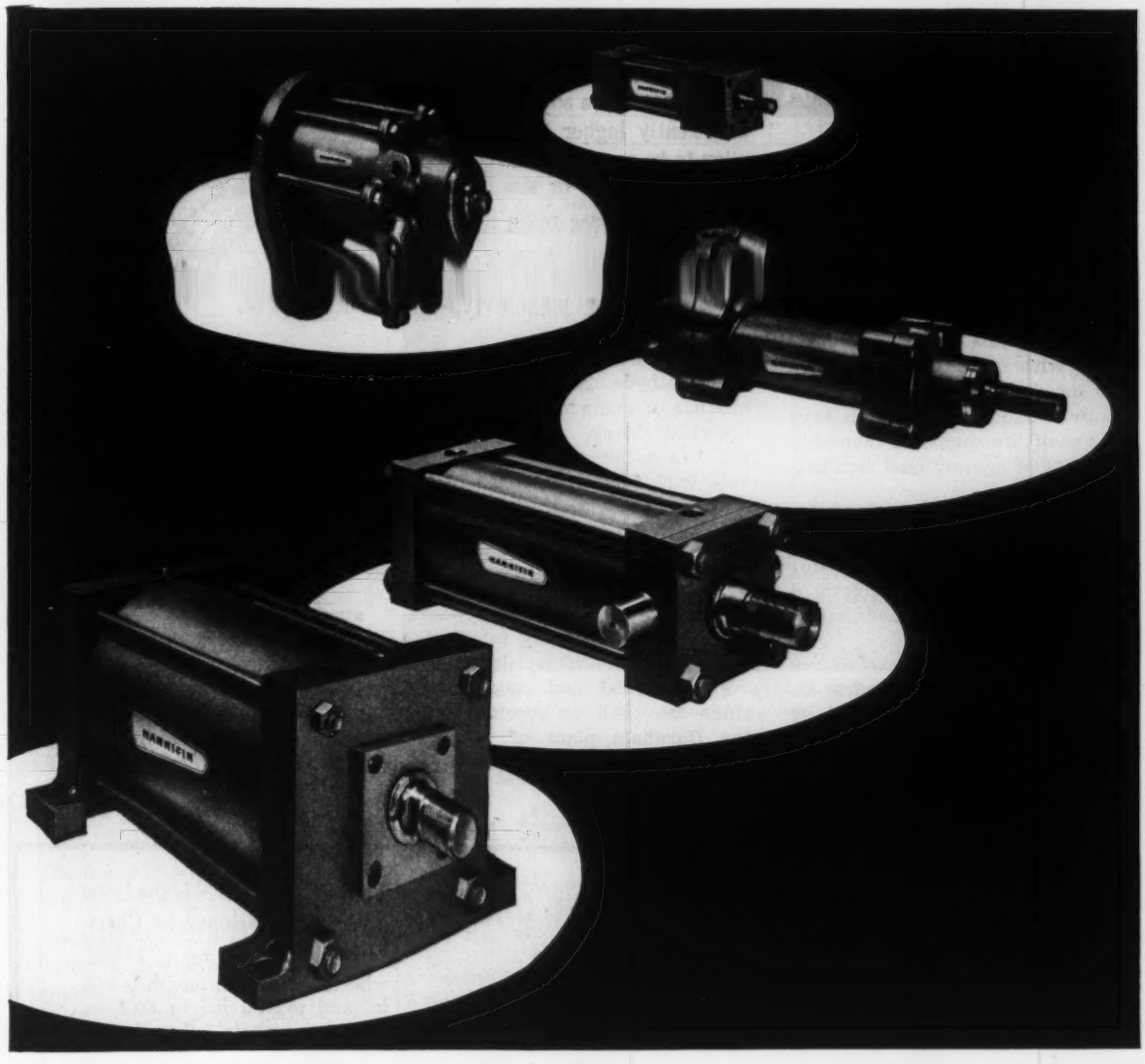
New High-Gloss Plastic Is Rigid, Wear-Resistant

NEW YORK — A new polyethylene resin featuring the properties of rigidity, wear-resistance and high gloss is announced by Bakelite Co.

Named Bakelite polyethylene DXM-103, the new plastic is expected to improve sales appeal of a wide variety of consumer products, particularly housewares and toys. The added rigidity is significant in the production of larger-size moldings. High gloss of the new material is created by the resin's flow characteristics in the mold. Easy flow also eliminates flow lines.

In packaging, it is claimed the new material can make caps and

HANNIFIN AIR AND HYDRAULIC CYLINDERS



To the engineer who wants the best cylinder—in a hurry

In the selection and purchase of cylinders look for:

Completeness of Line. Hannifin makes *five* lines of air and hydraulic cylinders in a range of bore sizes and mounting styles to meet every requirement and preference.

Leadership in Design. Hannifin cylinders are built to exacting quality standards and extremely close tolerances to insure easy, accurate mounting. Hannifin has also introduced the *externally removable* and replaceable bronze gland cartridge, the most noteworthy improvement in cylinder design in the last 50 years.

Rapid Delivery. Hannifin can ship the cylinder you need in strokes up to 60" *in any normal quantity within 48 hours.*

Field Engineers, located in all principal cities, are as near as your telephone. Or, if your requirements are really urgent, call us at Des Plaines. Experienced sales engineers will handle your order.

HANNIFIN

MAIL THIS COUPON FOR PROMPT ACTION

- ☐ Have Field Engineer call at once
- ☐ Have Field Engineer stop by soon
- ☐ For the present, just send complete catalog information on Hannifin cylinders including prices

Hannifin Corporation, 515 S. Wolf Rd., Des Plaines, Ill.

Name.....*Title*.....

Company.....

Address.....

City.....*Zone*.....*State*.....

—ITEM 160—

closures more resistant to staining by chemical contents such as cosmetics, foods, oils, acids, and caustics.

New Dry Cells Have Alclad Cups

PITTSBURGH, PA.—Dry cell batteries with Alclad anodes have been developed recently but not to the production stage. Alcoa says their shelf life compares favorably with that of conventional zinc batteries.

Previously, attempts have been made to utilize aluminum, but either the aluminum can (anode) of the battery became perforated or an oxide film was built up to cause failure.

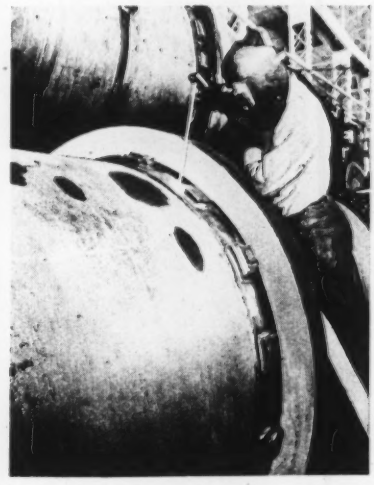
Research found that perforation of the can, caused by chemical attack, is completely eliminated by use of a duplex aluminum alloy.

Following the Alclad principle, the can is made up of two alloys metallurgically bonded together. The inner alloy has a solution potential sufficiently higher than the outer alloy to be consumed preferentially during discharge or storage. The outer alloy serves as an inert barrier, preventing pinhole type of attack.

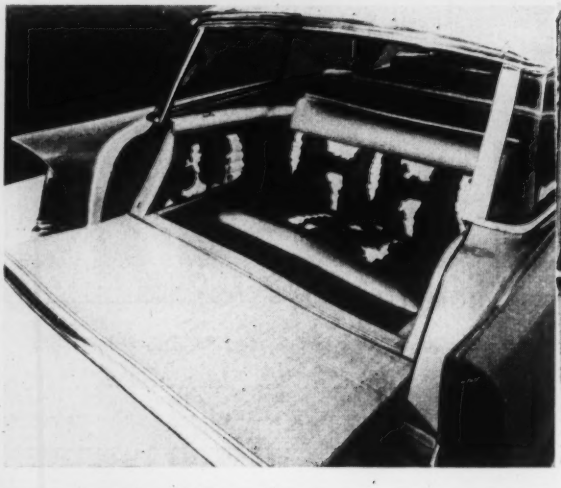
The aluminum cell employs the same cathode as the zinc cell—a mixture of manganese dioxide and acetylene black. The aluminum cell has a potential of about 1.6 volts with African ore and 1.7 volts or higher with synthetic ore.

"Floating tires" of steel provide for heat expansion of the cylindrical shells and simplify fabrication in Ruggles-Cole rotary dryers.

Forge rolled and rough-turned rings are used as received from the Burnham plant of Standard Steel Works. Dimensional tolerances are liberal because the rings are assembled on the dryer shell by wedging a number of steel blocks under them at equal intervals around the shell. The wedge blocks are then welded to the shell, and retainer blocks are welded on

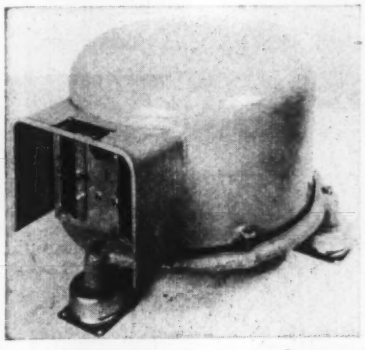


THE PLAINSMAN is the latest dream car developed by Chrysler Corp. Built on a 115-in. wheelbase, overall length is 208 in. and overall height 60.2 in. Features include all-steel top, two-thirds covered with white fabric, and with fresh air intake on step-riser. Spare wheel is lowered and raised with crank. Seats are covered with calf hide. Rear two face backward and are entered by steps which emerge when tail gate lowers. Experimental only, the Plainsman is not for sale



alternate ends of the wedges. A steel block is also welded on the inside of the rings before assembly to prevent rolling on the dryer shell.

Elimination of machining operations and the durability of forgings are advantages claimed for this construction.



UNIVAC MODEL ERA 1114 magnetic information-storage drum has a capacity of 42,000 binary digits or magnetized spots of information. A product of Remington Rand, ERA 1114 operates with electronic computers, punched-card equipment, electric typewriters, high-speed printers or graphic displays. Construction is intended to withstand extreme environmental conditions

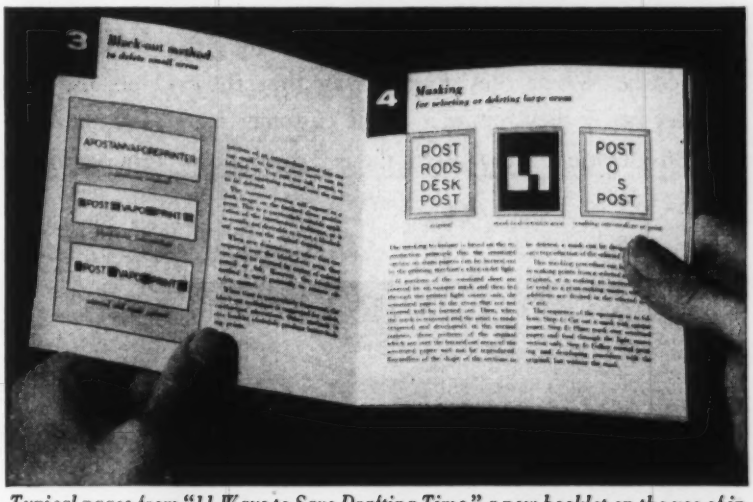
Low Frequency Ultrasonics Clean Miniature Bearings

PORT WASHINGTON, N. Y.—A recent report prepared for the Sperry Gyroscope Co. indicates that a low-frequency ultrasonics technique has been used successfully to clean high-precision antifriction ball bearings. Results obtained suggest applications of the process to other small, precision components.

Because of increased demands for greater accuracy, low frictional torque, and high operating speeds, superprecision antifriction bearings require that the highest degree of freedom from all foreign

(*Continued on Page 22*)

DRAFTING TRENDS



Typical pages from "11 Ways to Save Drafting Time," a new booklet on the use of intermediates and the first of its kind ever published. Each technique is fully described.

New booklet offers time-saving drafting tips

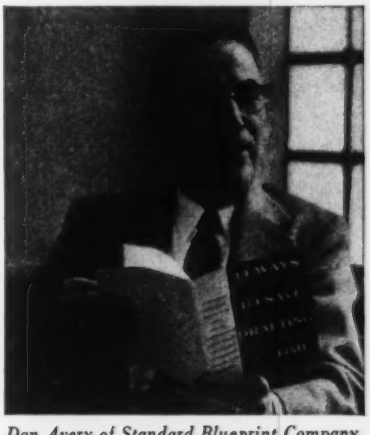
An interesting new booklet called "11 Ways to Save Drafting Time" is now available without charge to engineers and draftsmen. Published by Frederick Post Company, it's the first booklet that compiles the many ways of using *intermediates* to modify drawings without changing the original.

As most draftsmen know, an intermediate is any translucent reproduction master printed from an original drawing. Once the drawing is printed on the intermediate, this "duplicate master" serves as the source for future print making. By modifying only the intermediate and leaving the original unchanged, draftsmen save valuable hours of tracing and redrawing.

The booklet shows 11 specific ways of using intermediates to make changes, each one illustrated with examples. Some of the techniques covered are scissor editing, masking, the block-out method, successive additions and preprinting.

The other methods shown are transparent matte tape, pick-off transfer, composite grouping, composite overlays, non-reproducible blue and use of corrector fluids.

The techniques described apply to various print-making methods such as moist-developed process, ammonia process, blueprint, sepia negative and even reproduction cloths in some instances.



Dan Avery of Standard Blueprint Company, Cedar Rapids, who works with draftsmen daily, discovers helpful techniques in the new "11 Ways" booklet.

Further information on the new "11 Ways" booklet is available from the Reader Service Division of the Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18.

POST

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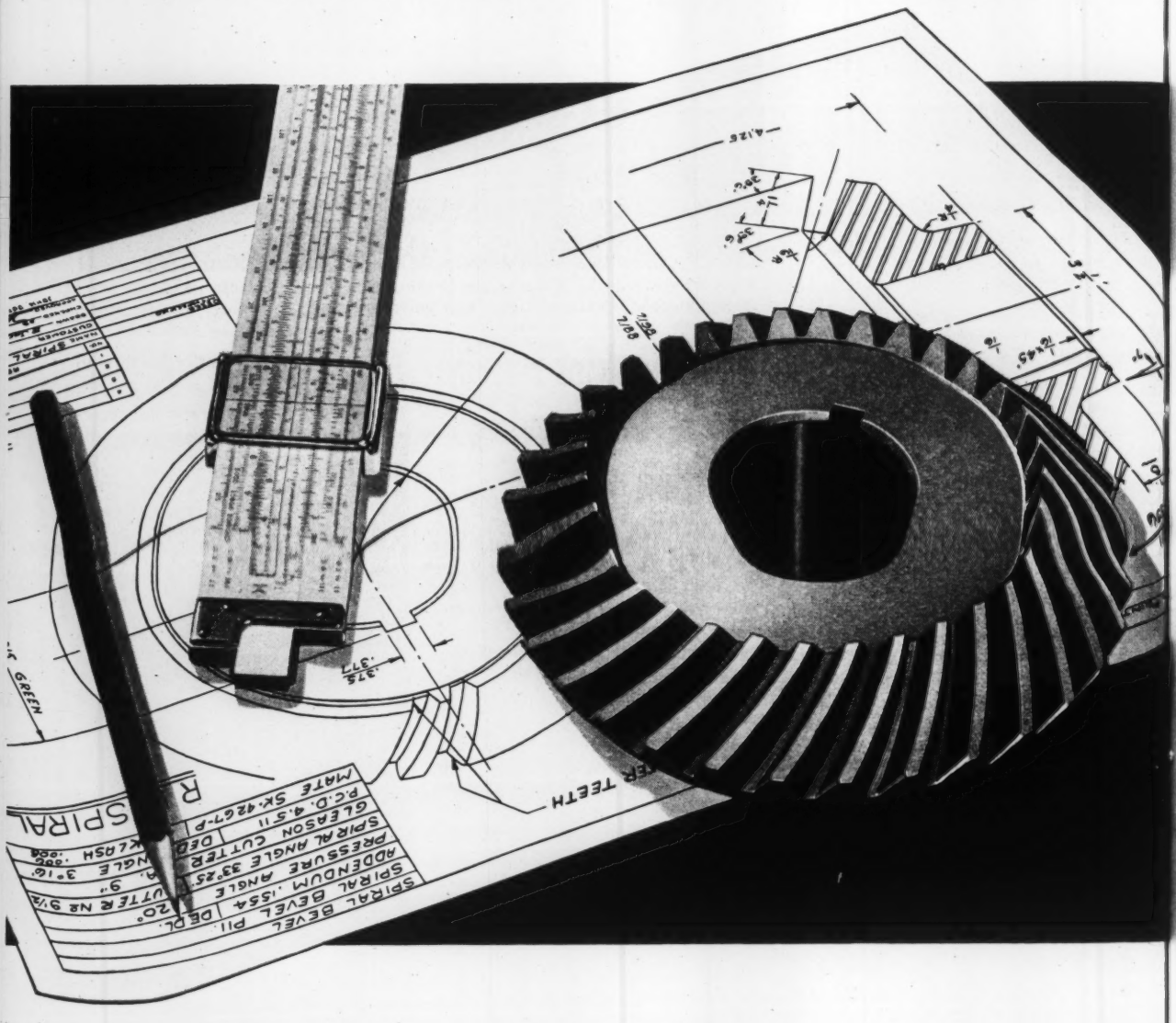
—ITEM 161—

"ENGINEERED QUOTATIONS"

When our engineers study our customers' prints, they look for ways to improve gear performance, ways to simplify gear installations, ways to cut gear costs. When they find a way that they consider better they report it to the customer for his consideration. Very often these "engineered quotations" are accepted. Such careful scrutiny of every engineering and manufacturing step by *gear specialists* is one reason why so many manufacturers use Automotive Gear Works as their "gear department". May we submit an "engineered quotation" on your gear requirements?



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FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Automotive Gear Works, inc.

ESTABLISHED IN 1914

RICHMOND, INDIANA

Reader Information Service

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CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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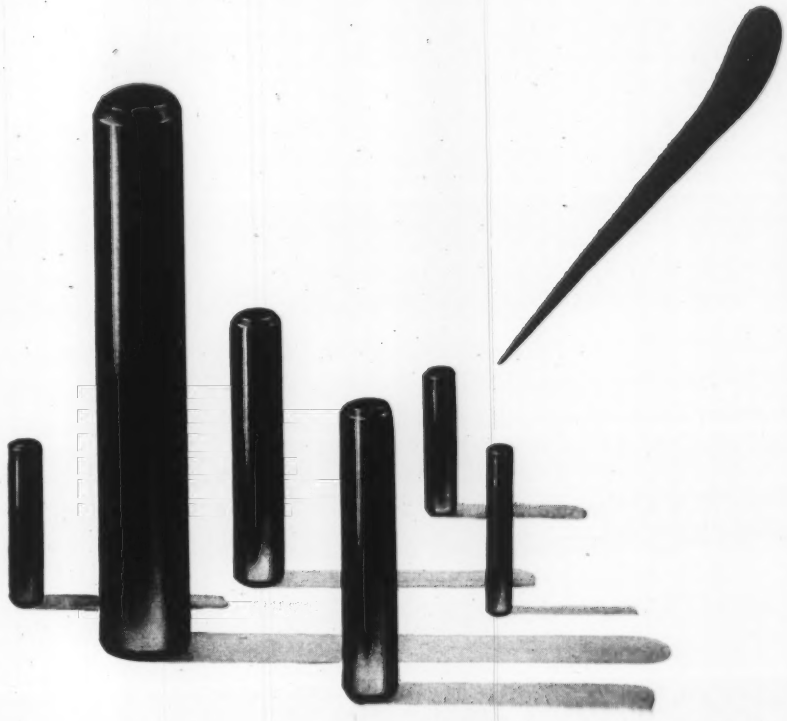

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That black lustre finish on all Holo-Krome Dowel Pins is a double benefit to you . . . *at no extra cost!* It retards corrosion and rusting of the highly polished surface . . . and the black finish acts as a lubricant.

With H-K Dowel Pins, driving is easier and there's less chance of seriously scoring the pin and mating parts. For dowel pins with *extras* . . . for dowel pins *individually inspected* . . . the name to remember is HOLO-KROME.

HK . . . First with Same-Day Service on *All* Catalog Items!

HOLO-KROME

HOLO-KROME SCREW CORP. • HARTFORD 10, CONN., U.S.A.

—ITEM 163—

For More Information Circle Item Number on Yellow Card—page 19

No Chippage when you use

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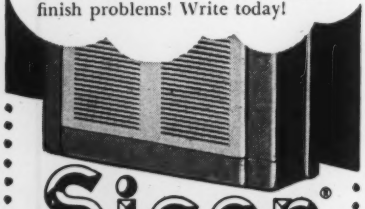
SILICONE

HEAT RESISTANT FINISH

PROVED by over 25,000 TEMCO Wall Heater Installations

The upper grille of this handsome TEMCO Gas Wall Heater is finished with 7x7070 Brown SICON

Silicone-Base Heat Resistant Finish. The number of louvers on this upper grille presented a chippage problem with vitreous enamel which prompted Temco to turn to SICON. Normal operating temperatures run about 350° F. but the temperature encountered on blocked flue conditions require a heat resistant finish to withstand 500° F...SICON 7x7070 Brown, on 25,000 or more Temco installations, has successfully met field performance requirements without loss of color, gloss or adhesion. Investigate other case histories of SICON—the remarkable finish that has solved over 150 heat resistant finish problems! Write today!



Sicon®

The Original Silicone Base Heat Resistant Finish

MIDLAND Industrial Finishes Co.

Waukegan, Illinois

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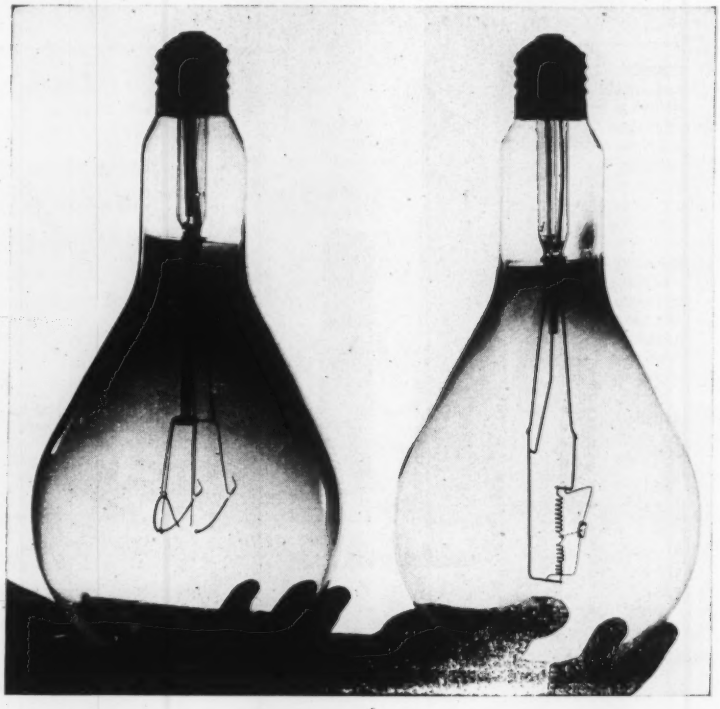
LACQUERS • VARNISHES

—ITEM 164—



BEFORE AND AFTER: Conventional light bulb, left, has been improved, according to General Electric Co., by converting from a circular to an axially positioned filament, right. About 15 per cent more light output for the life of the lamp is claimed to be the advantage. Blackening, as shown in the burnt-out bulb, left, covers most of the inside surface area. The axial type changes the flow of convection currents within the bulb so the blackened area is more concentrated

(*continued from Page* 15)

matter be obtained and maintained.

With bearing speeds as high as 24,000 rpm and radial clearance less than 0.0002 in., even the smallest particle of soil can influence bearing performance.

High-frequency ultrasonic equipment has exhibited some degree of cleaning ability, but the ultrasonic energy is concentrated in a small area. Since this energy is radiated in the form of a relatively narrow beam, it left untreated areas in the beam shadows. Cleaning tests with low-frequency ultrasonics were then initiated.

In the first cleaning with ultrasonics operating at approximately 16 kc/sec on a laboratory basis, 90 of 100 bearings passed the torque tests.

Special clips pick up and release individual bearings without manually touching them. Bearings are supported by their inner raceways; the outer raceway rotates by action of the low-frequency ultrasonic energy.

In a modified apparatus, provisions were made to circulate the solvent and filter it. A porous stainless-steel filter removes particles larger than 10 microns.

Rejects of cleaned bearings dropped from 10 out of 100 to 4 or 5 out of 1000. Cleaning time was reduced from 120 seconds to approximately 3 seconds.

Other parts cleaned successfully in this way include instrument lead screws, zero-backlash gears, jewel and plain bearings for clocks and meters, fine-pitch threads and components of hydraulic systems.

General Electric Co. has purchased "substantially all" the assets of the Watson Flagg Co. of

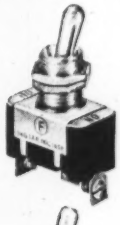
"Stop crying... I told you to use a Circle F switch!"

We at Circle F have long realized that a high "QSP" rating is most important to a growing business

- Top Quality so that customers can depend on your product
- Excellent Service to help clients with electrical problems
- Lowest Prices to assure a good margin of profit.

Check the "QSP" rating before you buy—we at Circle F proudly boast that our "QSP" is among the highest.

A complete line of switches are available in each of the classifications shown. For more information or individual consultation fill out the coupon below.



NO. L-42-E

Single Pole—Medium Duty—One Hole Mounting—Slow Make and Break—Solid "Fine" Silver Contacts "Off" Position in center.

NO. L-50-N

Double Pole—One Hole Mounting—Slow Make and Break—Solid "Fine" Silver Contacts—no "Off" Position.

NO. S-20-E

One Hole Mounting—Slow Make and Break—Silver Plated Contacts "Off" Position in center.

NO. 2230

Snap-In Appliance Switch.

Circle F Mfg. Co.

TRENTON N.J.
SAVING YOU MORE SINCE 1904

50 YEARS

Eastern Insulated Wire Corp.
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A subsidiary

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☐ Please send me catalogue of complete line of switches.

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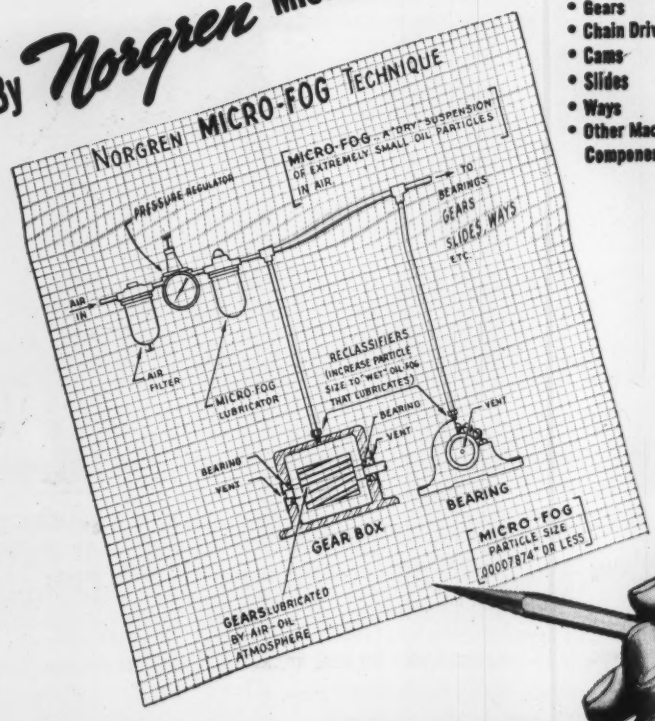
MACHINE WEAR REDUCED TO A MINIMUM

By Norgren MICRO-FOG Lubrication

For
- Bearings
- Gears
- Chain Drives
- Cams
- Slides
- Ways
- Other Machine Components

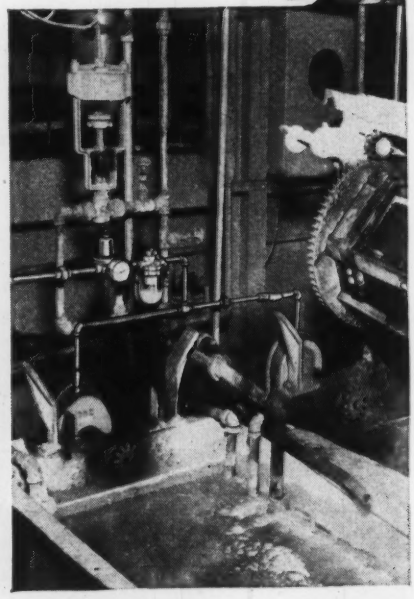

NORGREN MICRO-FOG TECHNIQUE
MICRO-FOG - A "DRY" SUSPENSION OF EXTREMELY SMALL OIL PARTICLES IN AIR
PRESSURE REGULATOR
AIR IN
AIR FILTER
MICRO-FOG LUBRICATOR
TO BEARINGS GEARS SLIDES, WAYS ETC.
RECLASSIFIERS (INCREASE PARTICLE SIZE TO "WET" OIL FOG THAT LUBRICATES)
BEARING VENT
BEARING VENT
GEAR BOX
BEARING
MICRO-FOG PARTICLE SIZE .00007874" OR LESS
GEARS LUBRICATED BY AIR-OIL ATMOSPHERE

Norgren MICRO-FOG Ends Gear Lubrication Problem On Zinc Plating Tanks

At the Wagner Electric Corp., St. Louis, baskets containing parts to be zinc plated in a hot acid solution are mechanically agitated by a gear drive.

With the former drip feed lubrication method, acid fumes entered the gear boxes, contaminating the lubricant and destroying the gear box seals. Loss of lubricant plus corrosion by the contaminated lubricant greatly accelerated gear wear and resulted in frequent costly repairs.

Three years ago, the Norgren MICRO-FOG Lubrication System at right was installed. The gears are constantly protected from wear by a film of oil — and entry of acid fumes is prevented by the slight, continuous flow of air through the gear box, venting to the atmosphere. Gear wear and corrosion have been reduced to a minimum.



C.A. Norgren CO.

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for complete details on this application — or call your nearby Norgren Representative listed in your telephone book.

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PRESSURE REGULATORS • AIR LINE FILTERS • LUBRICATORS • AIR CONTROL VALVES

—ITEM 166—
For More Information Circle Item Number on Yellow Card—page 19

News Roundup

Paterson, N. J., supplier of gearmotor components to GE. A new department which permits consolidation of GE gearmotor business is formed in the Watson Flagg plant.

Meetings

AND EXPOSITIONS

Feb. 26-29—

American Institute of Chemical Engineers. Winter Meeting to be held at Hotel Statler, Los Angeles, Calif. F. J. Van Antwerpen, 120 E. 41st St., New York 17, N. Y., is secretary.

Feb. 27-March 2—

American Society for Testing Materials. National Meeting to be held at Hotel Statler, Buffalo, N. Y. Additional information may be obtained from society headquarters, 1916 Race St., Philadelphia 3, Pa.

March 6-8—

Society of Automotive Engineers. National Passenger Car, Body and Materials Meeting to be held at Hotel Statler, Detroit, Mich. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

March 8-9—

The Society of the Plastics Industry, Canada, Inc. Fourteenth Annual SPI Canadian Conference to be held at the Sheraton-Brock Hotel, Niagara Falls, Ontario, Canada. Additional information may be obtained from society headquarters, 67 West 44th St., New York 36, N. Y.

March 12-15—

National Electrical Manufacturers Association. Midwinter Meeting to be held at the Edgewater Beach Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 155 East 44th St., New York 17, N. Y.

March 12-16—

National Association of Corro-

sion Engineers. Twelfth Annual Conference and Corrosion Show to be held at Hotel Statler, New York, N. Y. A. B. Campbell, 1061 M & M Bldg., Houston 2, Texas, is executive secretary.

March 14-15—

American Society of Mechanical Engineers. Engineering Management Conference to be held at Hotel Statler, St. Louis, Mo. Additional information may be obtained from society headquarters, 29 West 39th St., New York, N. Y.

March 14-16—

American Society of Mechanical Engineers. Aviation Division Conference to be held at Hotel Statler, Los Angeles, Calif. Additional information may be obtained from society headquarters, 29 West 39th St., New York, N. Y.

March 14-16—

Pressed Metal Institute. Annual Spring Technical Meeting to be held at the Carter Hotel, Cleveland, Ohio. H. A. Daschner, 3673 Lee Rd., Cleveland 20, Ohio, is managing director.

March 18-21—

American Society of Mechanical Engineers. Spring Meeting to be held at the Multnomah Hotel, Portland, Ore. Additional information may be obtained from society headquarters, 29 West 39th St., New York, N. Y.

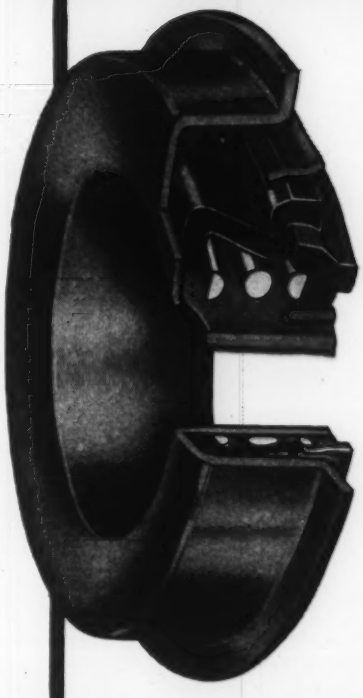
May 14-17—

Design Engineering Show and Conference to be held at Convention Hall, Philadelphia, Pa. Additional information may be obtained from Clapp & Poliak, 341 Madison Ave., New York 17, N. Y.

May 24-25—

Third Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsored by the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information may be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

YOU ASSURE...



Greater Economy
Better Performance
WITH
JOHN CRANE
SELF-ALIGNING
TYPE 11-A
Rotary Shaft
SEALS

BECAUSE:

1. **You save on production time.** The Type 11-A Seal is a low cost, compact, factory assembled unit. Its "pressed-in" cartridge-type construction makes for quick installation as equipment rolls by.
2. **One seal size fits several shaft diameters.** Retainer is so constructed that it does not contact the shaft, eliminating the need to "switch" seals when shaft specifications vary slightly.
3. **Damaging stresses are eliminated.** Since the entire unit remains stationary, the seal readily lends itself to applications involving high speed and vibration.
4. **Safeguarded against corrosion.** Metal spring utilized to maintain constant contact of sealing faces is fully enclosed in synthetic rubber bellows. This eliminates the need for costly corrosion-resistant spring materials.

"John Crane" Type 11-A Seals are recommended for temperatures to 212°F., pressures to 20 psi. Available in four stock sizes from ⅛" to ¾".

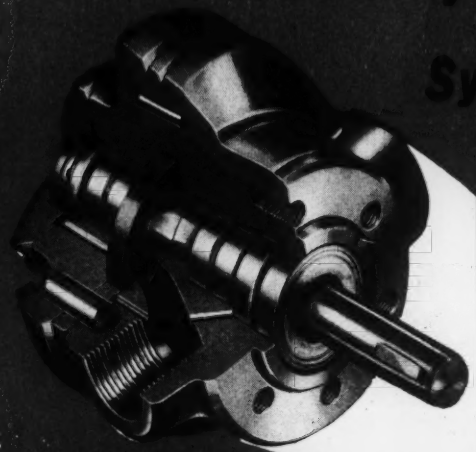
Contact "John Crane" engineers on your requirements today. Request illustrated catalog on complete line of seals for all services.

Crane Packing Co., 6425 Oakton St., Morton Grove, Ill. (Chicago Suburb). *In Canada: Crane Packing Co., Ltd. Hamilton, Ont.*

JOHN CRANE CRANE PACKING COMPANY 38 YEARS INDUSTRIAL PROGRESS

—ITEM 167—

How to Engineer Dependability into Your Hydraulic System...



Specify Gerotor Hydraulic Pumps

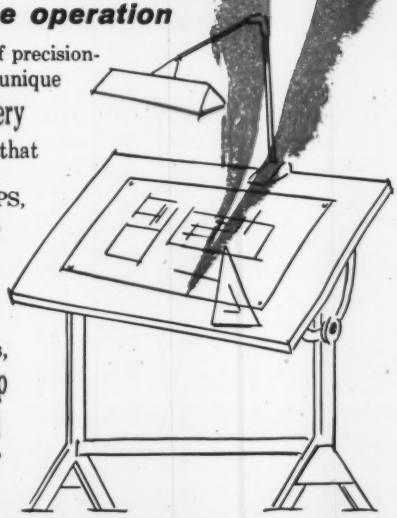
Years of trouble-free operation

are yours with the GEROTOR line of precision-manufactured hydraulic pumps. The unique GEROTOR principle . . . heart of every GEROTOR pump . . . is so designed that friction is reduced to a minimum.

GEROTOR HYDRAULIC PUMPS, designed into your hydraulic systems, assure lower maintenance costs over longer life. Standard GEROTOR pumps are available in capacities ranging from .4 g.p.m. to 40 g.p.m.

Due to modern production facilities, GEROTOR can produce special pump designs in *quantities* on an economical basis. Whatever your hydraulic pump problems, bring them to GEROTOR.

FREE literature available . . . *write:*



GEROTOR

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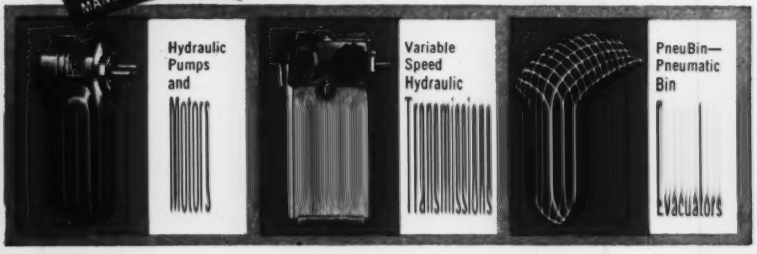
MANUFACTURERS OF—

1537 MARYLAND AVENUE, BALTIMORE 3, MARYLAND



—ITEM 168—

For More Information Circle Item Number on Yellow Card—page 19

MEN

OF MACHINES

William S. Miller has joined the staff of MACHINE DESIGN as an associate editor. A graduate of the University of Delaware with a B.S. in mechanical engineering, Mr. Miller also received a master's degree in aeronautical engineering from Cornell University. Concurrent with his graduate work he was

William S. Miller

engaged in an optical instrumentation project for the U. S. Navy at Cornell. During World War II Mr. Miller served with the U. S. Air Force as an aircraft engineering officer. In 1949 he joined the Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics, Cleveland, as a member of the Physics Div. doing research instrumentation. He advanced to group leader in this division, then transferred to power plant analysis work in the Engine Research Div. Mr. Miller is a member of the Institute of the Aeronautical Sciences.

Fairchild Camera and Instrument Corp., Syosset, N. Y., has announced the appointment of **Milton A. Chaffee** as director of electronics and systems research. He was formerly deputy director of

systems at the Air Force Cambridge Research center in Cambridge, Mass.

Alan M. Glover has been named general manager of the newly created Semiconductor Div. of Radio Corp. of America. Dr. Glover will make his headquarters at the RCA plant in Harrison, N. J., until a new plant which will house semiconductor engineering and additional manufacturing facilities is completed at Somerville, N. J., later this year.

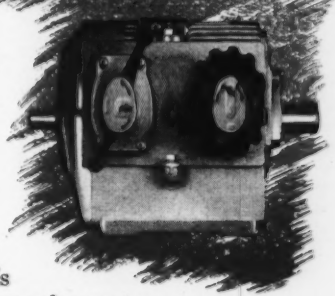
Glenn L. Martin Co., Baltimore, prime contractor for the launching system for the United States' artificial earth satellite, has appointed **N. Elliott Felt Jr.** operations manager of this project. Mr. Felt, who has been associated with Martin since 1951, was responsible for designing the guidance system of the company's Viking rocket.

Formerly electronics project engineer, **John Velesky** was recently promoted to chief engineer of Wac Engineering Co., Dayton, O.

Louis N. Ridenour has been named director of the research laboratories of the Lockheed Missile Systems division in Van Nuys, Calif. Dr. Ridenour has served for approximately a year as program development director at the division. Active in radar and electronics development during World War II, he headed work at the Massachusetts Institute of Tech-

Louis N. Ridenour

If you could hire a Gnu...



The ungainly Gnu is considered to be a most flexible beast. He has six speeds forward, can make prodigious leaps, can turn on a dime, and even back-up at an acceptable speed. However, the Gnu has to take a back seat in the flexibility department to the new GEROTOR VARIABLE SPEED HYDRAULIC TRANSMISSION. This new transmission has infinitely variable speeds—up to 1500 rpm—in *either* direction, can reverse itself instantly, has completely self-contained controls, can be mounted easily with standard motor to fit just about any situation. Better cancel your plans to hire the Gnu and make rapid inquiries about the new GEROTOR VARIABLE SPEED HYDRAULIC TRANSMISSION . . . *write:*

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MANUFACTURERS OF—

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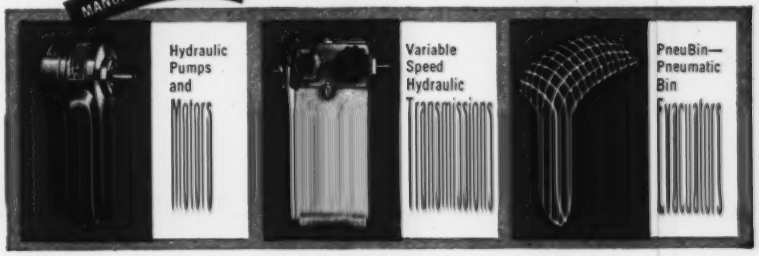
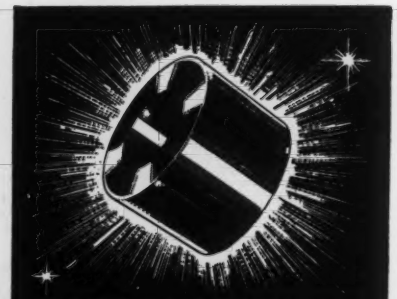


—ITEM 169—



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LONG WEARING
LOW FRICTION

UNIQUE (OIL-FREE)

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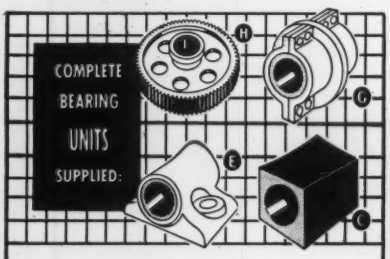
BUSHINGS

EXCELLENT DURABILITY • CONSTANT COEFFICIENT OF FRICTION • APPLICABLE OVER A WIDE TEMPERATURE RANGE (-450° to +700°F.) OPERATE DRY, OR AT HIGH SPEEDS SUBMERGED IN WATER, GASOLINE OR LIQUID GASES • NON-CONTAMINATING IN FOODSTUFFS • EXCELLENT FOR CURRENT-CARRYING BEARINGS

GRAPHALLOY is widely used for self-lubricating piston rings, seal rings, thrust and friction washers, pump vanes.



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GRAPHALLOY has high-performance electrical properties: low electrical noise, low and constant contact drop, high current density, minimum wear!

Brush Holders and Assemblies, Coin Silver Slip Rings and Assemblies available.

USE OUR 40 YEARS OF DESIGN EXPERIENCE!

GRAPHITE METALLIZING CORPORATION

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☐ Send data on BRUSHES and CONTACTS.

NAME & TITLE
COMPANY
STREET
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—ITEM 170—

nology Radiation Laboratory which led to the SCR 584 anti-aircraft radar system.

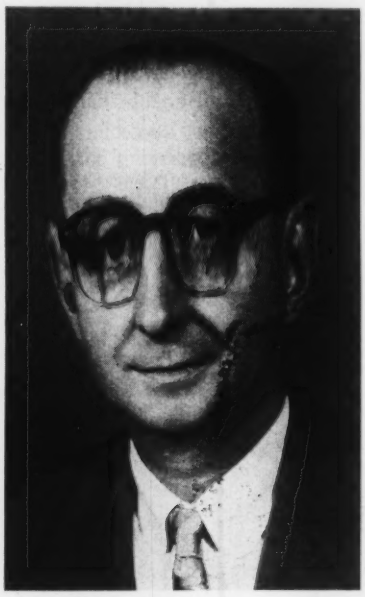
Sten Soderberg has been promoted to director of engineering by Leslie Co., Lyndhurst, N. J. Mr. Soderberg joined Leslie Co. in 1926 as chief engineer.

St. Regis Paper Co. has announced the appointment of **Eli Hartz** as manager of the vacuum forming plant of the Panelyte Div., Richmond, Ind. Mr. Hartz had served as chief engineer of the Panelyte plant at St. Jean, Quebec, and is succeeded in that position by **Jack Sibalis,** formerly assistant chief engineer.

Clarence Wantz has been appointed chief engineer in charge of the engineering department of Robertshaw Thermostat Div. of Robertshaw-Fulton Controls Co. at Youngwood, Pa. Mr. Wantz, who developed automatic timer controls for top burners of gas ranges, has been associated with the company since 1952.

Fawick Airflex Div. of Fawick Corp., Cleveland, has appointed **W. E. Karr** chief engineer. He will be responsible for the development and application of pneumatic clutches, power transmission units and high-speed clutch controls. Mr. Karr previously had been associated with the International Harvester Co. in various engineering capacities and with Beloit Iron Works as division engineer in the design and application of hydraulic, mechanical and electrical drive units.

W. E. Karr



Douglas F. Illian has been named director of research and development for all plants and products of Tuttle & Kift Inc., Chicago, a subsidiary of Ferro Corp. Mr. Illian had been associated with Hotpoint since 1941.

Lebanon Steel Foundry, Lebanon, Pa., has appointed **David C. Ekey** director of research.

Robert E. Sanford has been named design engineer by the Erie Foundry Co., Erie, Pa. He was formerly associated with Clearing Machine Corp. and prior to that, with National Machinery Co. as assistant to the chief engineer.

Computer - Measurements Corp., North Hollywood, Calif., has announced the appointment of **R. E. Lovejoy** as director of research for the counting and computing instrument division.

M. C. Patterson has been named vice president and car operations manager by Dodge Div. of Chrysler Corp., Detroit.

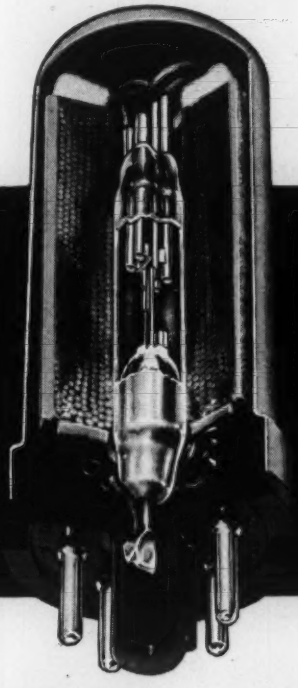
Reorganization of the engineering department of Burndy Engineering Co., Norwalk, Conn., has resulted in four new appointments. **Fred Heller** has been named engineering manager of the Utility-Industrial Div.; **Milton Leland** has been appointed engineering manager of the Original Equipment Manufacturers and Military Products Div.; **Henry P. Dupre** will continue to head the compression tooling group as Hytool Div. manager; and **Howard M. Levenson** will be in charge of the Quality Control Div.

Standard-Thomson Corp., Dayton, O., has appointed **Everett M. Patterson** to the position of executive engineer. Mr. Patterson has 27 years of experience in research and development work in the field of electronics and nucleonics.

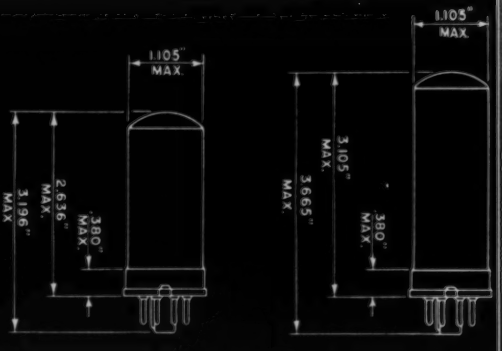
A BILLION OPERATIONS

. . . with no maintenance whatsoever

. . . from NEW CLARE Mercury-Wetted Contact Relays



• Cutaway view showing sealed-in-glass, mercury-wetted contact switch, surrounded by the operating coil and encased in a metal housing mounted on an octal base.



Type HG Relay — Type HGP Relay

CLARE Type HG and HGP Relays are built to meet the exacting requirements for—

Computing machines · Servo-mechanisms
Sorting machines · Relay amplifiers
Tabulating machines · High-speed keying relays
Totalizers · Signaling devices
All kinds of high-speed switching devices

Outstanding features of CLARE Type HG and HGP Relays

ELECTRICAL FEATURES

LONG LIFE: Conservative life expectancy of over a billion operations when operated within ratings.

HIGH SPEED: Give consistent performance at speeds up to 60 operations per second.

HIGH CURRENT- and voltage-handling capacity (up to 5 amperes, and up to 500 volts).

UNIFORMITY: Operating time varies by only about 0.1 millisecond under constant drive conditions.

CHATTER-FREE: Mercury dampens armature vibration and bridges mechanical chatter between metal contact surfaces.

MECHANICAL FEATURES

- Small chassis space required
- Convenient plug-in mounting
- Environment-free
- Tamperproof
- High sensitivity
- Maintenance-free
- No contact wear
- Adjustment cannot change

This first announcement of the new CLARE Mercury-Wetted Contact Relays is of especial importance to designers of high-speed switching machines and devices which demand accuracy and dependability of a high order.

In these relays, with their unique electrical and mechanical stability, you will find exactly the qualities this kind of apparatus requires—

—Long life (over a billion operations)
—High speed (up to 60 operations a second)
—High current- and voltage-handling capacity (up to 5 amperes, and up to 500 volts)
—Bounce- and chatter-free contacts
—Extraordinary uniformity of operation

These distinctive characteristics are achieved by the use of platinum contact surfaces, continuously wetted with mercury by capillary action, and the hermetic sealing of a magnetic switch in a protected glass capsule, filled with pressurized hydrogen.

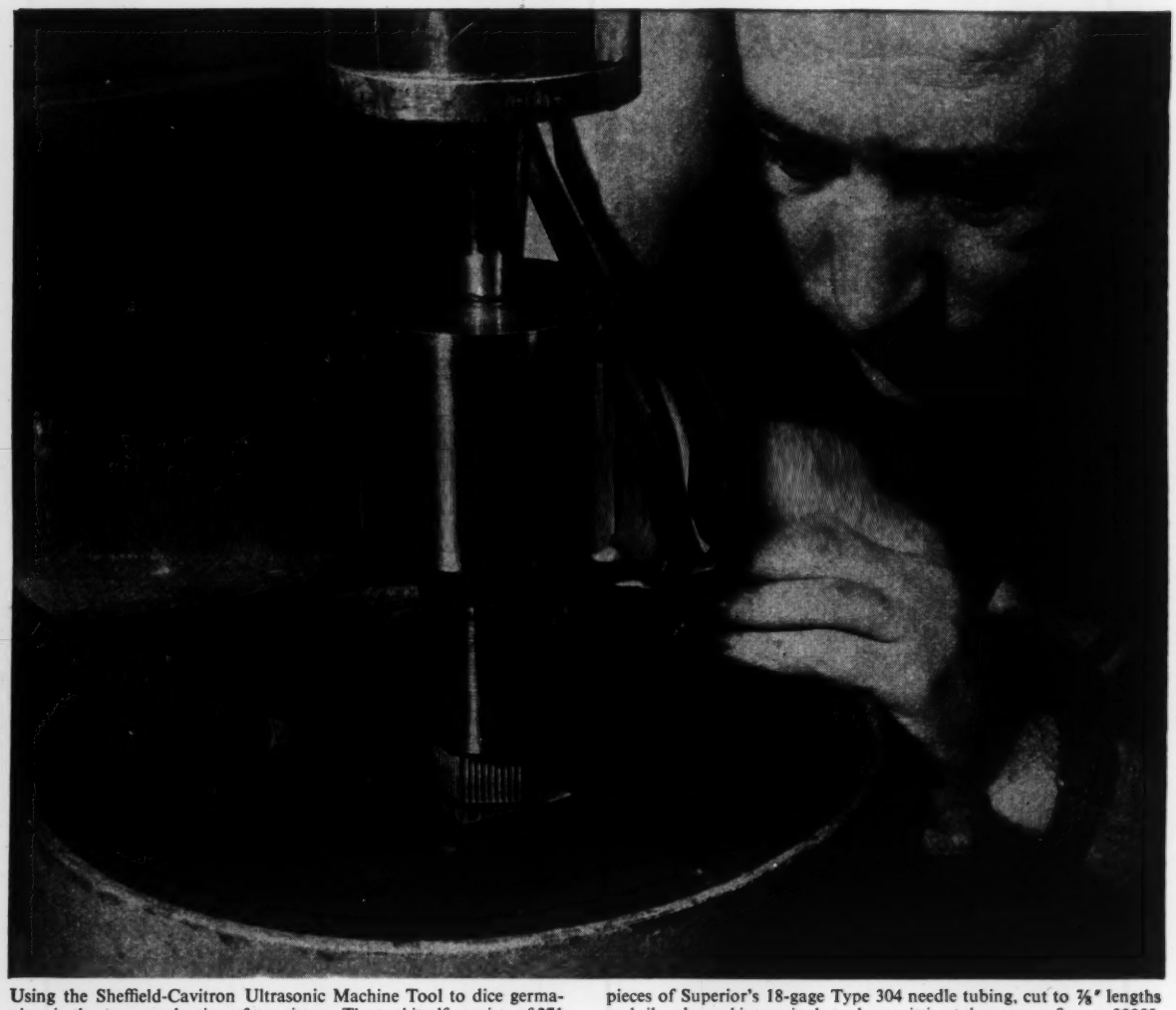
CLARE Type HG Relays comprise a switch element and an operating coil. CLARE Type HGP Relays are similar but can be factory-adjusted to provide either biased or polarized operating characteristics.

For complete information on the new CLARE Type HG and HGP Mercury-Wetted Contact Relays, contact your nearest CLARE representative or address C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois.

Send for CLARE Sales Engineering Bulletin No.120

CLARE RELAYS

FIRST IN THE INDUSTRIAL FIELD



Using the Sheffield-Cavitron Ultrasonic Machine Tool to dice germanium in the mass production of transistors. The tool itself consists of 271 pieces of Superior's 18-gage Type 304 needle tubing, cut to 7/8" lengths and silver brazed into a single tool, permitting tolerances as fine as .0005".

NEW ULTRASONIC MACHINE TOOL USES TUBING TO CUT HARDEST, MOST BRITTLE MATERIALS KNOWN

a new application for Superior Tubing

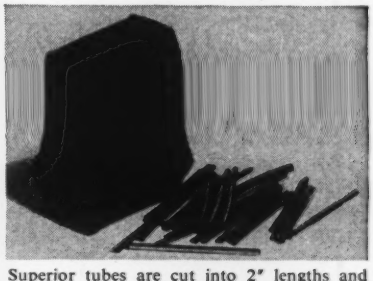
Ultrasonic vibrations do the cutting with this new machine tool, invented and developed by the Cavitron Equipment Corporation, Long Island City, N.Y. In the Cavitron process, a tool is used which has the precise shape of the cavity desired. Finely divided abrasive particles suspended in water are flowed continuously across the work. No movement or vibration is visible when the machine is switched on, although the tool tip vibrates 20,000 times a second through a stroke of .0035". The vibrating tip activates the suspended particles, and microscopic chips are gently excavated without heat, noise or vibration. The tool sinks swiftly into the work under slight pressure, forming a cut or cavity of exactly the same shape as the tip.

Tools made of Superior tubing save considerable cutting time on relatively large areas. Furthermore, the slender walls (.005" thick) minimize waste of valuable raw material. Cavitron engineers first used carbon tubing for this purpose, but in consultation with Superior engineers switched to AISI Type 304. This material has twice the life of carbon tubing, with much greater resistance to wear. Most important, it resists warping at the silver brazing temperatures needed to join the tubes together.

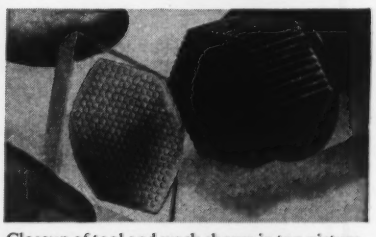
Your files should contain Superior Bulletin No. 40. It lists over 55 types of available material, including the stainless steels, with valuable selection and application data. Write for your free copy today. SUPERIOR TUBE COMPANY, 2010 Germantown Ave., Norristown, Pa. *On the West Coast:* Pacific Tube Co., 5710 Smithway St., Los Angeles 22, California.

All analyses available in .010" to 5/8" OD; certain analyses in light walls up to 2 1/2" OD

Superior Tube
The big name in small tubing



Superior tubes are cut into 2" lengths and silver brazed into a 6-sided tool, which is then cut in half and two complete honeycomblike tools formed—each 7/8" deep. Similar tools are used to cut precision jewel bearings.



Closeup of tool and work shown in top picture. The Cavitron makes it possible to cut and drill intricate shapes in materials which, because of their frangibility or sensitivity to sudden temperature changes, would be impossible to work on a production basis.

—ITEM 172—
For More Information Circle Item Number on Yellow Card—page 19

New ASCO 3-Way Solenoid Valve assures MILLIONS OF

TROUBLE-FREE OPERATIONS

NO EQUAL IN SIMPLICITY!

Simplicity is the secret of this remarkable, new 3-way diaphragm valve. It has *only three operating parts.* Compare this with the larger number of parts found in conventional 3-ways! That's one reason why the new ASCO valve means trouble-free operation . . . substantial savings in maintenance costs . . . reduction in down-time losses.

The EXTRA HEAVY FORGED BRASS BODY houses only three moving parts: Two diaphragms and a core. Corrosion protection is assured. All parts in contact with fluids or gases are brass, stainless steel or Buna-N.

SIMPLICITY IN OPERATION

Not only its construction but also its new operating principle is the essence of simplicity: solenoid piloting of two simple diaphragms.

UP TO 400 CYCLES PER MINUTE

Exceptionally large flow capacity makes rapid recycling feasible . . . cylinders fill and vent rapidly . . . valve operates up to 400 cycles per minute over millions of strokes.

CONVERTS IN 30 SECONDS

Developed for dependable control of liquids and gases, the valve can be converted from normally open to normally closed or the reverse by simple rotation of the valve bonnet.

This new valve is absolutely tight seating . . . no closely fitted parts or valve seat grinding required. Available now in ⅜" and ½" pipe sizes, both with full ⅜" orifices, it can be mounted in any position.

WRITE NOW for your copy of ASCO Bulletin 8316, or have the ASCO Engineer call.

ASCO®

DEPENDABLE CONTROL

AUTOMATIC SWITCH COMPANY • 387 LAKESIDE AVENUE • ORANGE, NEW JERSEY

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

—ITEM 173—

For More Information Circle Item Number on Yellow Card—page 19

Here's Why Clifford Specifies ALL-ANGL Barry Mounts to Protect Reliability thru Every Flight Attitude —of the F-100 Super Sabre

Clifford miniaturized heat-control unit — only 3-1/8 inches high.

It's an important story of engineering for shock and vibration control

North American Aviation, builders of the F-100 Super Sabre, specify that the control box must be able to mount at any angle. MIL-E-5272A requires the mount to operate under vibration as high as 0.080" double amplitude. Temperature requirements preclude the use of rubber mountings. And experience demands that the mounting system handle the load bias added by large connectors and cables — often a serious problem with miniaturized equipment.

Because they are specifically designed for jet and missile service, ALL-ANGL Barry Mounts meet all these requirements. So Clifford's choice of this mount assures the protection of their new miniaturized heat control under every operational condition.

The ALL-ANGL Barrymount® isolators used in the Clifford base are standard miniature size. These advanced-design mountings are also available in MIL-size 1 and (Feb. 1) MIL-size 2. Write for data sheets.

When your problem is protection through all flight attitudes, your answer is ALL-ANGL Barry Mounts. For recommendations, call your Barry Sales Representative.

BARRY B MOUNT

BARRY CONTROLS
INCORPORATED
SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

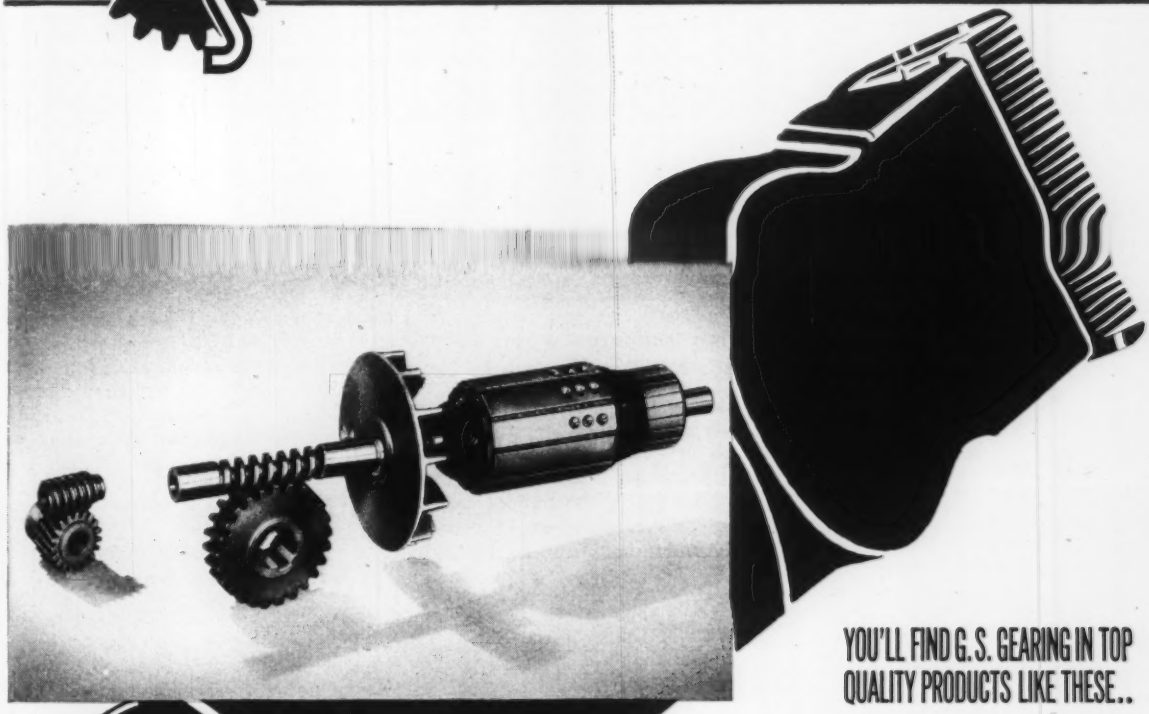
New engineering opportunities are open in Barry's expansion program, at all levels in all departments. Send resumé.

722 PLEASANT STREET, WATERTOWN 72, MASS.

—ITEM 174—
For More Information Circle Item Number on Yellow Card—page 19

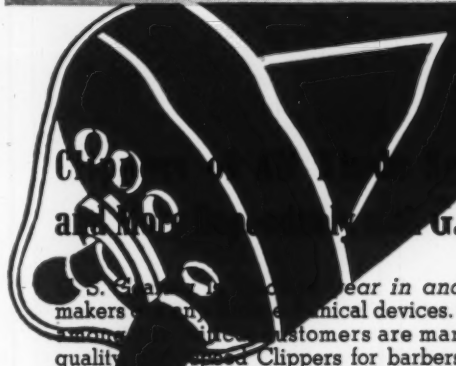
FRACTIONAL HORSEPOWER GEARING

40 Years of Specializing in Small Gearing!



YOU'LL FIND G.S. GEARING IN TOP QUALITY PRODUCTS LIKE THESE..

Aircraft Carburetor & Fuel Metering Systems • Aircraft Instruments & Radios • Automatic Musical Instruments • Business Machines • Communication Equipment • Electric Fans • Electric Motors • Floor Polishers, Scrubbers & Sanders • Food and Drink Mixers • Home Appliances • Meat Tenderizers, Grinders & Slicers • Military Equipment • Motion Picture Equipment • Outboard Motors • Pneumatic Production Tools • Portable Electrical Tools • Radio Dials • Sewing & Cloth Cutting Machines • Steelstrap Stretchers • Step Switches • Vending Machines.



e Longer G.S. Gearing

ear in and year out by the makers nical devices. Listed prominently ustomers are manufacturers of top quality Clippers for barbers, hedge trimming, anima ing and others. Extreme *uniform* G. S. accuracy is a r equirement to assure the purring performance and l r life of these very successful products.

If trans itting power is involved in the products you make, chances are we can help you, too! Remember please, we've *specialized* on the design and quantity production of Small Gearing, from 8 to 96 dp, for more than 40 years. Through never ending research . . the development and perfection of men, methods and machines . . we've reached a position of leadership in this field! Specifying "G. S." is your guarantee of getting Small Gearing that consistently measures up to the *most exacting* specifications. Will you tell us just how we can best serve you NOW?

SEND FOR FREE *6-page Small Gearing Guide. It describes 80 types and applications. Contains useful charts . . a valuable aid to anyone interested in Small Gearing. Use company letterhead, please. No obligation, of course. Write today!*

GEAR Specialties, Inc.

2635 WEST MEDILL AVENUE
CHICAGO 47, ILLINOIS

SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARING

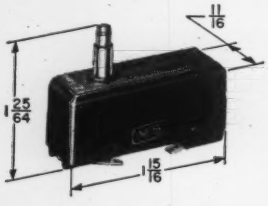
—ITEM 175—

(Advertisement)

Uses Unlimited for

Saves 87% in cost . . . 85% in space on tapping machine

"Any other switch that would do this job would cost eight times as much and require a control box seven times as big," according to the designer of the tapping machine in which it functions as a master control.



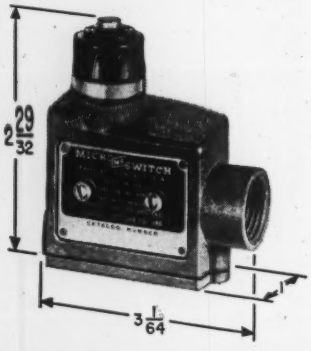
A single "on and off" MICRO precision switch must operate 96,000 times a day under extremely close tolerances. Its performance is a dramatic example of the simplified design, operating accuracy and economy which may be effected by the use of MICRO precision switches.

In this instance the compact switch design and its extreme reliability over millions of accurate operations were important factors in its selection.

Five switches are "watchdogs" on automatic labeling machine

MICRO precision switches are the electrically-operated "watchdogs" which help permit an automatic labeling machine to operate at speeds of from 90 to 180 bottles a minute.

Located at strategic points they prevent picking up a label unless there is a bottle in position to receive it; stop the machine if a bottle is in

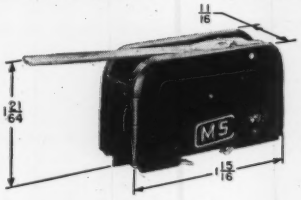


position to be broken; and control the label picking and gumming mechanisms.

Designers of this ingenious machine selected MICRO precision switches as important components because of their precise, dependable operation, their quick response to slight operating force and sealed actuating plungers to resist entrance of dust and dirt.

Switch indicates when bobbin needs refilling on fabric loom

Automatic warning of empty bobbins on fabric looms has been provided by MICRO precision switches. If there is no filling on the bobbin, a feeler bar slides along the bobbin causing its upper end to press against the switch and signal the need for refilling.



The switch used for this application met these exacting requirements:

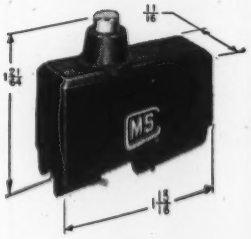
- Rugged construction to withstand the constant to and fro movement of the lay (120 to 180 picks a minute).
- Rugged wiring terminals to allow heavy wire attachments. (#16 stranded or over).
- Light operating pressure to allow slipping feeler tip lever to indicate.
- Sufficient overtravel to allow feeler tip lever to slip without injury to the switch.

Center stop motion on this same loom is controlled by two other MICRO precision switches.

Provide flexible operation of automatic gear valve controls

Nine MICRO precision switches are used in a 4-train gear limit assembly to control automatically the operation of valves on steam, air, gas, water and oil lines.

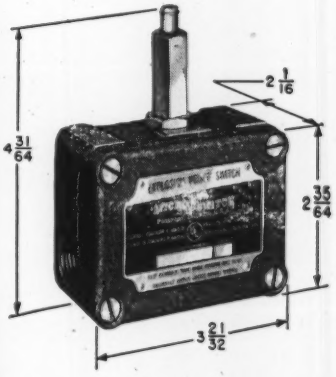
Eight of them permit adjustments in the gear train to open and close different circuits with rotations of the drive shaft. The ninth cuts off the motor if the design torque load is exceeded.



Design engineers selected the MICRO SWITCH units for this important application because of (1) high electrical capacity; (2) extremely rapid make and break action; (3) provision of more electrical circuits and (4) small size to aid compact design.

Switch "tells" level in bins and storage tanks

A compact, sensitive, explosion-proof switch was required by engineers who designed an automatic level control for enclosed bins and tanks.

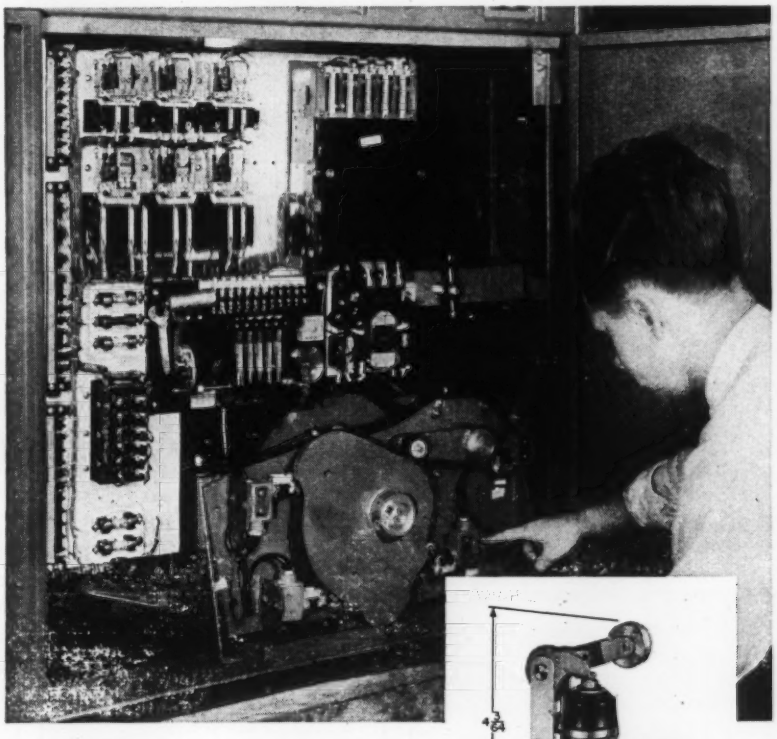


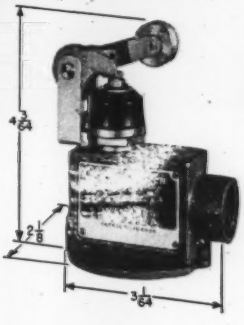
Two switches are used in each installation to start and stop the conveyors and keep the stored material at the proper level. A plastic float ball is attached to the housing in which the MICRO SWITCH explosion-proof switch is mounted. Pressure of the materials against this plastic ball actuates a rod which in turn actuates the MICRO SWITCH unit to open or close the electrical circuit.

The MICRO SWITCH unit chosen is the smallest, most compact explosion-proof switch available. It provided the dependability, sensitivity and ruggedness this application demanded. It is also enclosed for protection against dirt and dust and for use in hazardous atmospheres.

MICRO precision switches

...THEIR USE IS A PRINCIPLE OF GOOD DESIGN





4 switches make gear hardening a completely automatic operation

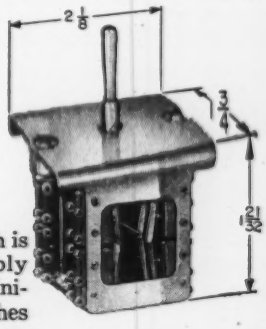
Gear hardening at the rate of 60 per hour is really a sensational performance. This kind of unfailing performance through long sustained service depends on the precise and automatic control of the cycles of handling, heating, quenching and unloading.

The MICRO SWITCH units shown were selected by the design engineers, to provide this completely automatic operation.

Their selection was prompted by their precise operation, the ease with which they could be mounted, the water-tight connections provided and the long-life trouble-free performance for which MICRO SWITCH products are famous.

The switch selected is enclosed in a die-cast aluminum housing and has a roller arm actuator which is adjustable vertically at intervals of 0.18 degrees through 225 degrees . . . horizontally to any position through 360 degrees. A synthetic rubber boot covers the plunger and a gasketed bottom plate protects the enclosed switch from dirt, dust, and splash of oil or water.

Provides accurate multiple circuit control in jet aircraft



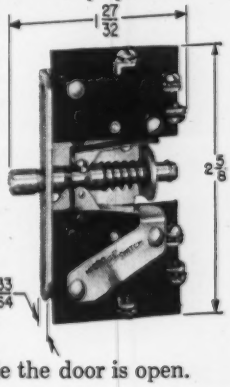
This switch is an assembly of 16 subminiature switches which is operated by a single bat handle.

Eight of the switches are operated with each direction of the toggle motion to control important electrical circuits in a jet fighter aircraft.

The assembly provides an unusually efficient, compact, lightweight component. The subminiature switches are less than ¾" long and weigh less than 1/15 of an ounce.

MICRO SWITCH provides a full line of toggle switches to meet the widest variety of uses. Some are hermetically sealed for immunity against altitude or environmental changes.

Door interlock switch for electronic equipment



In this double switch assembly, one switch turns current off when the high-voltage cabinet drawer is opened. The other flashes warning if current is turned on manually while the door is open.

The designer selected the MICRO SWITCH unit because of its small size and complete dependability to give sure, automatic protection to high-voltage equipment and personnel.

Send for new Catalog 83 on Industrial enclosed switches.

MICRO SWITCH Engineering Service is available to help you select the exact switch to meet your design problem. Call the MICRO SWITCH branch nearest you.

MICRO SWITCH

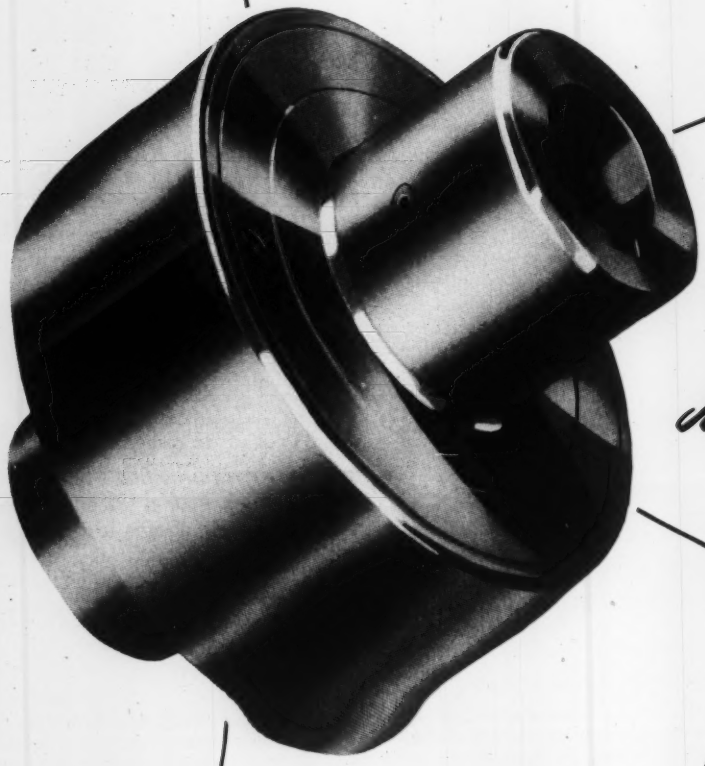
A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

—ITEM 176—

Accent *on Craftsmanship*

for better power drives



Expert Engineering

Masterful Design

Skillful Production

Skilled Centric craftsmanship of design and engineering in the field of power transmission, plus accurate production control have made available a complete line of standard Centric Centrifugal Clutch-Couplings and Clutches—a line that is second to none in motor, indirect, engine and dual drive performance.

The expert engineering, controlled fabrication, all under the same management throughout the years, is your assurance of high standards and complete satisfaction in solving any drive problem.

For smooth cushion starts, complete acceleration control and overload protection install Centrics.

And now we have added to the established Centric line—the new Centric Trig-O-Matic Overload Release Clutch.

Your inquiry is invited

CENTRIC *Clutch Company*

212

P. O. BOX 175 • U. S. ROUTE 9 AT MAIN STREET • WOODBRIDGE, NEW JERSEY

—ITEM 177—

For More Information Circle Item Number on Yellow Card—page 19

Facing Page—ITEM 178→

MELTING FORGING HEAT TREATING MACHINING

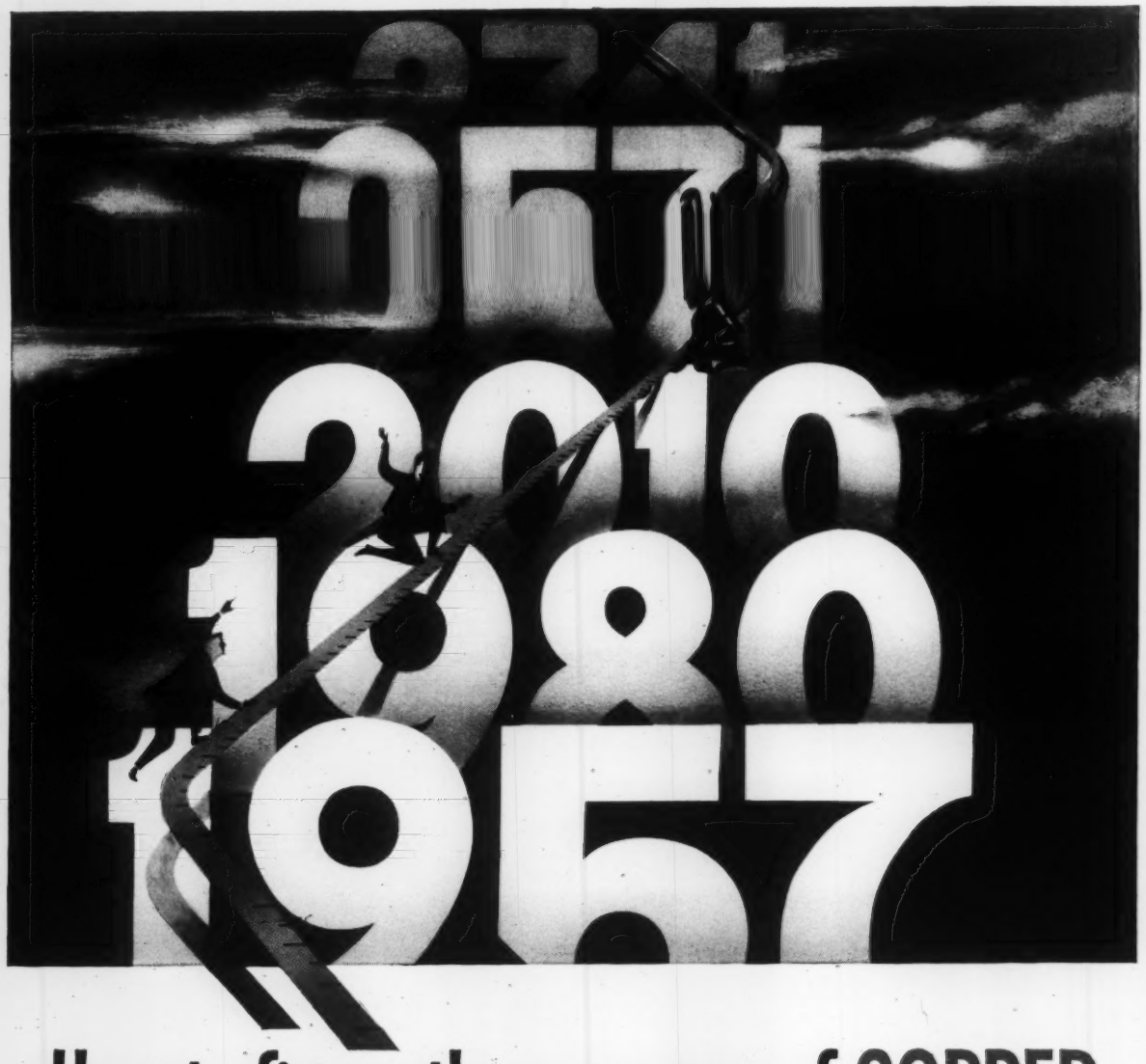
"THE WHOLE BALL OF WAX"

Complete Steel Forging Facilities from Melt to Finished Product for Heavy Press Forgings of Intricate Shape . . . . . Write

Cameron

IRON WORKS, Inc.

SPECIAL PRODUCTS DEPARTMENT
P. O. Box 1212, Houston, Texas



How to figure the economy of COPPER

You can evaluate copper, very simply...by looking forward.

Not backward, to yesterday. Not inward, on the problems of today. But *forward*, to tomorrow.

For the economy of using copper is *ultimate* economy. What substitute costs less than copper . . . or gives you better value . . . whenever you can figure cost *by the year?*

The copper roof on Philadelphia's Christ Church is 200 years old. The hardware in Mount Vernon has been used since Colonial days. Copper water lines have been found in Egypt dating from 3400 B. C. And brass pipes in Boston's Parker House were originally installed in 1854.

What will people say about *your* product years after they've bought it? If you use copper, they will say what men have said through the ages: "See . . . it pays to buy *quality!*"

When the reputation of your product is involved, make it with copper! Copper & Brass Research Association, 420 Lexington Avenue, New York 17, New York.

COPPER & BRASS
RESEARCH ASSOCIATION

. . . AN INDUSTRY SOURCE OF TECHNOLOGICAL AID, INCLUDING A LIBRARY OF TECHNICAL LITERATURE AND A COUNCIL OF SPECIALISTS

COPPER OR ITS ALLOYS PROVIDE THESE ADVANTAGES:

Best conductor of electricity commercially available

Does not rust . . . High corrosion resistance

Best heat transfer agent of all commercial metals

Easy to machine, form, draw, stamp, polish, plate, etc.

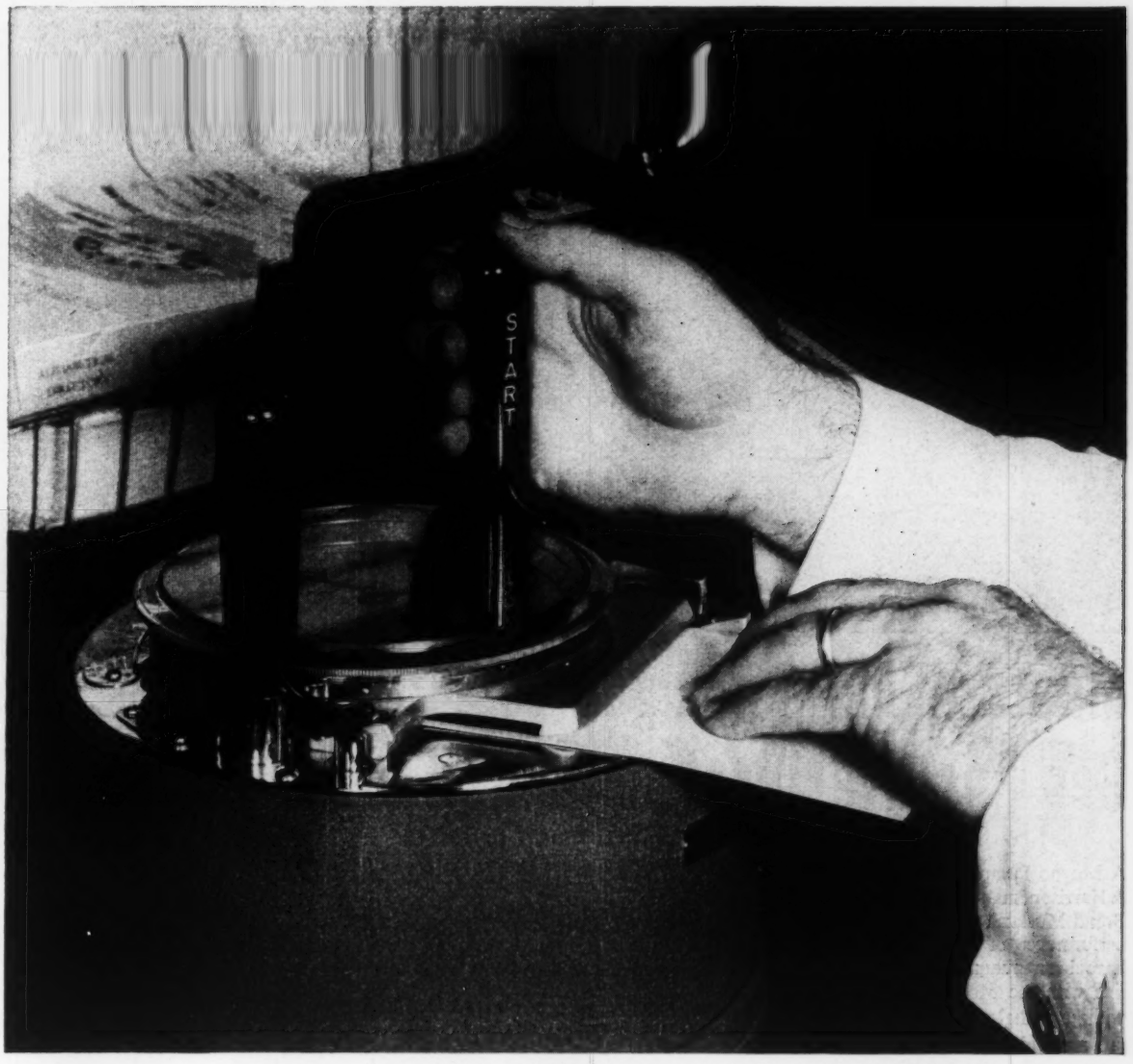
Welds readily . . . excellent for soldering and brazing

—ITEM 179—

For More Information Circle Item Number on Yellow Card—page 19

Another new development using

B. F. Goodrich Chemical *raw materials*



Ames Rubber Company, Hamburg, New Jersey makes the platen for Calculagraph Company, Harrison, New Jersey. B. F. Goodrich Chemical Company manufactures the Hycar American rubber only.

Time marches onto printed cards... with Hycar

HERE is a new automatic elapsed time recorder for use in parking lots, long distance switchboards —anywhere in industry where precise timing must be recorded on cards. It also computes time intervals.

There are many good reasons why the manufacturer selected Hycar American rubber for the printing platen. The platen needed to be soft enough to "give" under the impression, yet hard enough for a clear print. It had to be springy so no permanent impressions remained. And most important it could not swell or be attacked by the solvents in the ink. The manufacturer found that Hycar gave the exact combination of properties required.

Hycar American rubber has exceptional resistance to abrasion, oil, gas, heat and cold, as well as many chemicals. Throughout industry Hycar has solved many problems and improved many operations. It may supply the answer to your own product problems. Please write Dept. EJ-1, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B. F. Goodrich Chemical Company

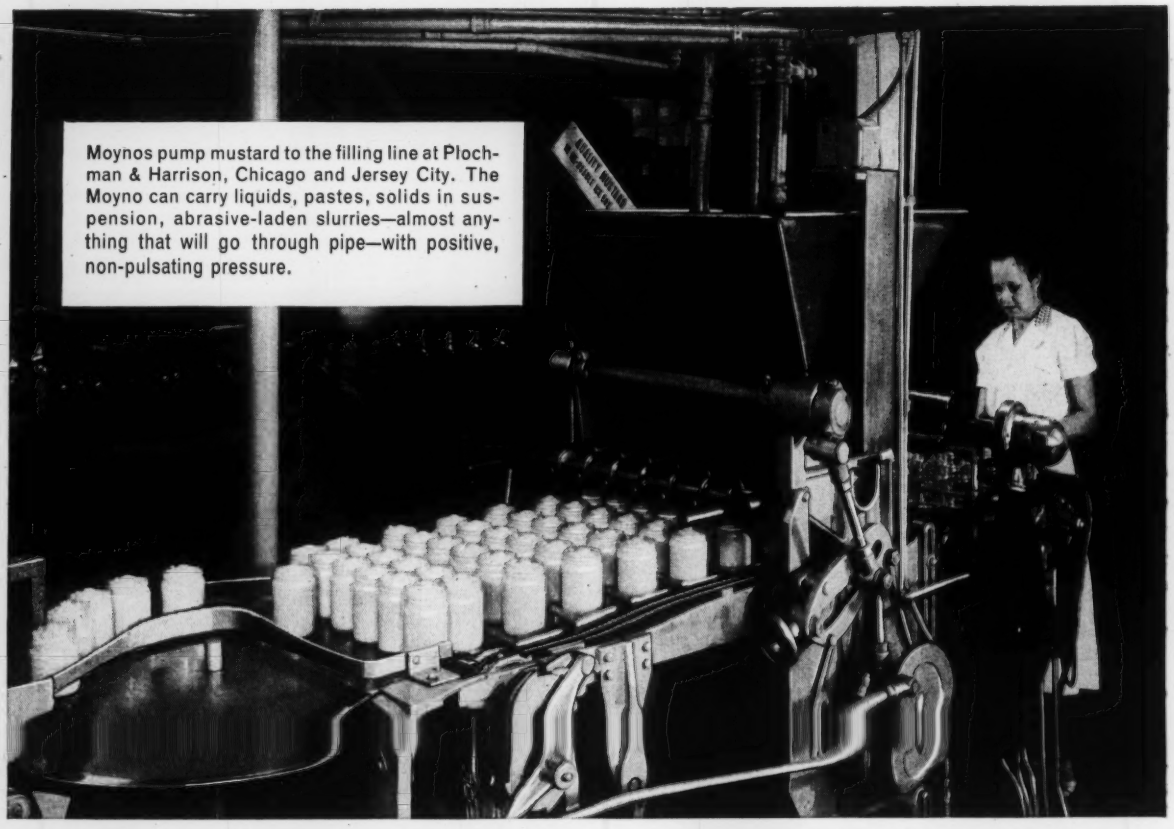
A Division of The B. F. Goodrich Company

Hycar Reg. U.S. Pat. Off.

American Rubber

GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors

—ITEM 180—



Moynos pump mustard to the filling line at Plochman & Harrison, Chicago and Jersey City. The Moyno can carry liquids, pastes, solids in suspension, abrasive-laden slurries—almost anything that will go through pipe—with positive, non-pulsating pressure.

Mustard Mill Changes to MOYNO® Pumps to Get Positive Displacement, Longer Pump Life

A Moyno Pump installation at Plochman & Harrison, makers of the famous Premium Brand Mustard, illustrates the outstanding performance of the Moyno Pump. They have been pumping mustard to a filling line with the Moyno for over two years without a single replacement of parts. They are replacing other pumps with Moynos.

The mustard is pumped as a semi-solid. In addition, it has both an acid and an abrasive content which causes other pumps to wear out in a few months. Moynos handle a wide variety of products that are not pumpable with other types of pumps. These include potato salad, chow mein, fruit, acid, alkalis, pastes, abrasive slurries, paints, tar, cement, plaster, many others.

The Moyno has a unique rotor and stator arrangement which forms sealed progressing cavities that move the material, providing positive displacement. For this mustard handling job parts were made of stainless steel to assure trouble-free service and long pump life. Rotor and stator are available in other alloys, or plastic compositions.

Note the outstanding features of the Moyno shown at the right. Perhaps your pumping problems can be solved with the Moyno. Write us today! Ask for a free copy of Bulletin 30-MD. It will give you complete facts!

Features of the MOYNO that may solve YOUR pumping problem

Gentle: no churning; won't break up semi-solids . . . won't aerate liquids. May be used for metering.

Reversible: pumps with equal efficiency in either direction.

Trouble Free: self priming; won't cavitate or vapor-lock. Just one moving part—no valves to stick, no pistons to gum up. Built for tough service. Easy to maintain.

Positive Displacement: Moynos are available to pull up to a 29" vacuum while discharging under pressure. Big Moynos deliver up to 500 g.p.m. Pressures to 600 p.s.i. plus are available.

ROBBINS & MYERS, INC.

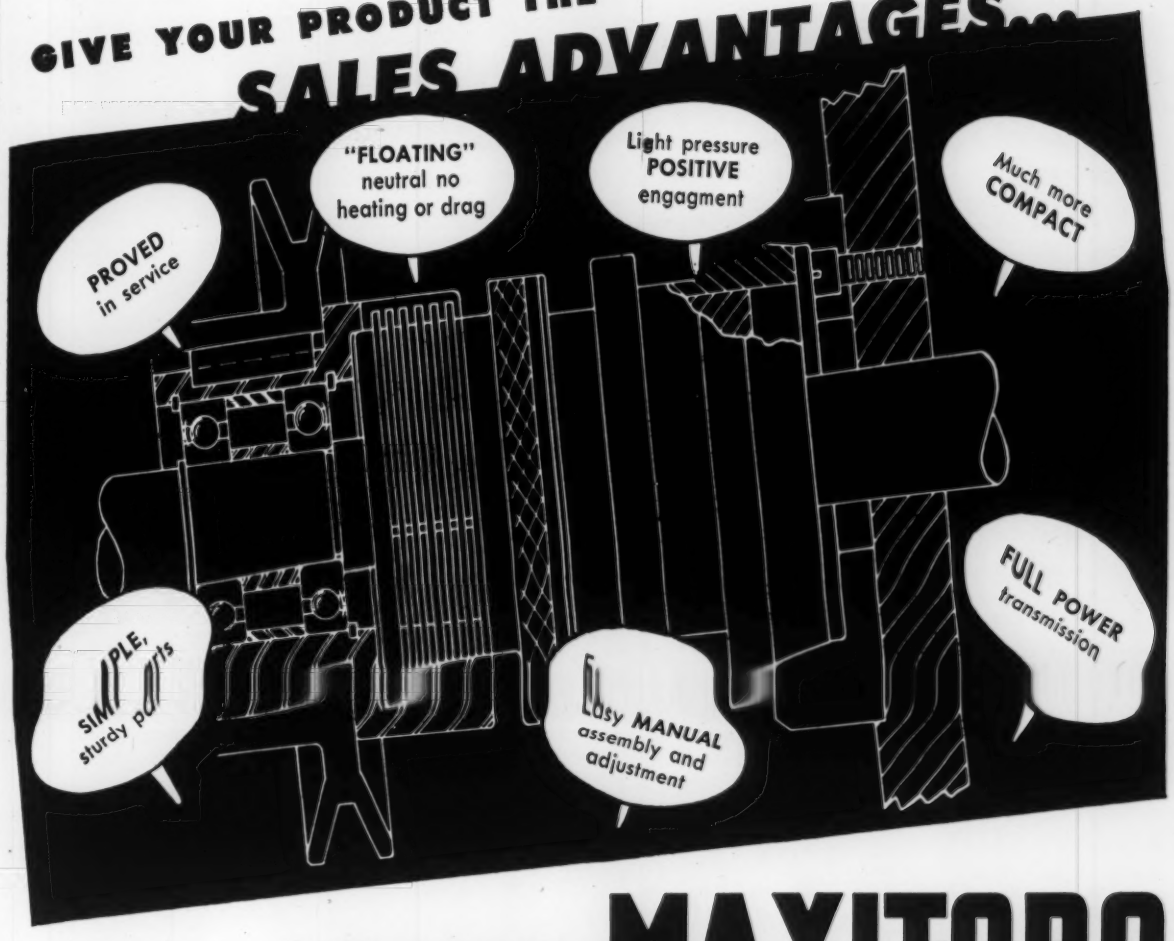
R&M®

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

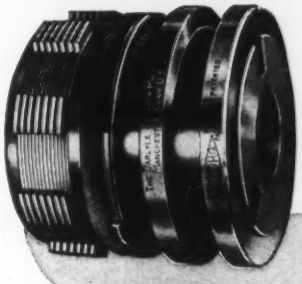
Fractional and Integral HP Motors | Household Fans | Hoists and Cranes | Large and Small Moyno Pumps | Propellair Industrial Ventilating Equipment

—ITEM 181—

GIVE YOUR PRODUCT THE SALES ADVANTAGES...

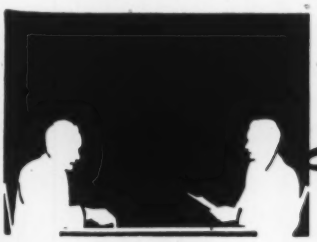


...OF A PROVEN MAXITORQ floating disc CLUTCH



The above line drawing illustrates a single MAXITORQ Clutch arranged for single V-belt drive with a special sliding beveled shifter sleeve acting as a light brake.

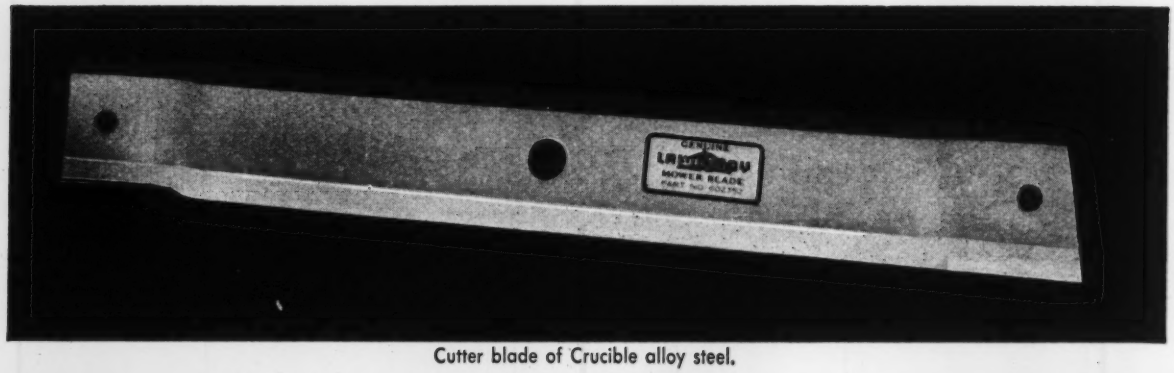
Yes, there are many types of MAXITORQ . . . single, double, overload release . . . to meet every installation need. Get our comprehensive technical data . . . let our engineering department help you work out special drive problems. Write or phone: Dept. MD-2, The Carlyle Johnson Machine Company, Manchester, Conn.



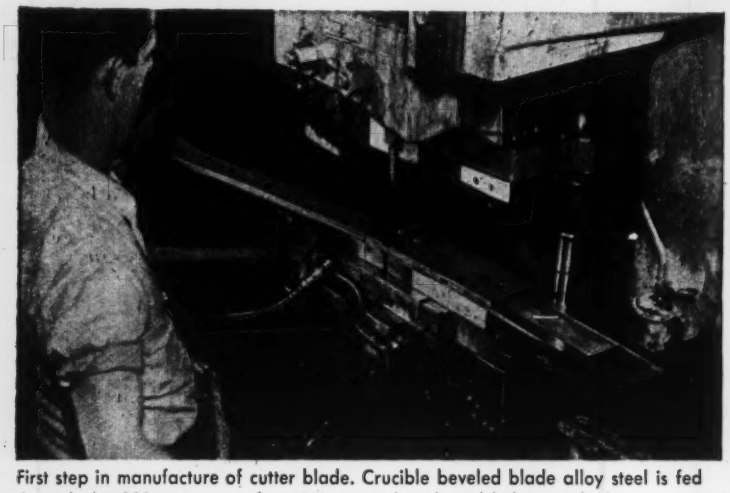
Let's talk MAXITORQ

SCJ55

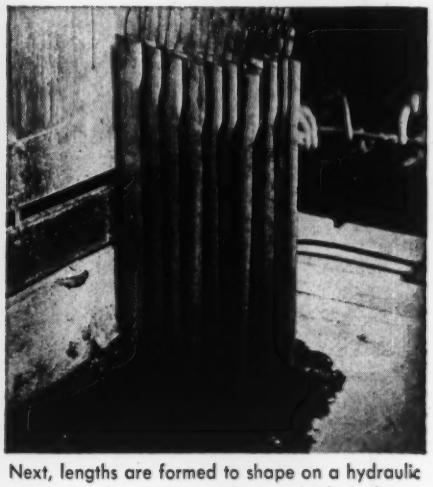
—ITEM 182—



Cutter blade of Crucible alloy steel.



First step in manufacture of cutter blade. Crucible beveled blade alloy steel is fed through this 100-ton press, where it is cut to length and holes punched.



Next, lengths are formed to shape on a hydraulic press, and then given a tempering bath as shown.

CRUCIBLE ALLOY STEEL *cuts blade damage in rotary mowers . . .*

Lawn-Boy mower. Built by RPM Manufacturing Co., Lamar, Mo., a subsidiary of Outboard, Marine & Manufacturing Company, maker of Johnson & Evinrude outboard motors.

Rotary lawnmower cutter blades, whirling at high speeds, often hit small rocks or bits of trash. Ordinary steels just can't take that sort of rugged treatment. They chip, crack – wear out far too quickly. That's why in leading mowers, like the new *Lawn-Boy*, you'll find special *alloy* steel cutter blades *designed for reliable performance.*

For Crucible has developed a *special alloy steel* made to give the best possible combination of toughness and hardness for long-lasting edges—and formability and ductility for ease of manufacture. It's been so successful that *Crucible is now the largest producer of lawnmower steels.*

Most Crucible steels are designed to fill *special* needs. If you have an application where ordinary steels won't do, come to Crucible. Take advantage, too, of the dozens of technical booklets and data sheets Crucible has prepared to help you make the best use of special steels. For a free publication catalog, write *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

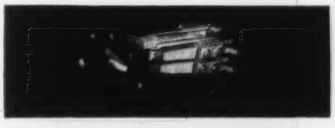
—ITEM 183—

Automatic Electric Key Switches

for the toughest kind of service!

These rugged key switches are made to give you the same long life and dependability you expect—and *get*—from Automatic Electric relays. The same design features and assembly techniques provide *permanently welded* contacts and contact springs that "stay put"—even under extremes of temperature, humidity and vibration. Choose these key switches for your toughest jobs.

LEVER KEY SWITCHES

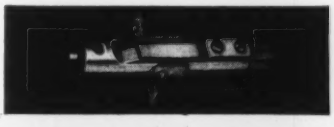


Supplied for one- or two-way operation. Up to 24 contact springs may be used in each position. Locking or non-locking in either position. For extraordinary shock and vibration, specify the "Shok-Lok" Lever Key Switch (described below).

TURN KEY SWITCHES

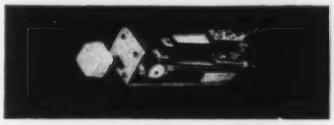
Designed for applications requiring locking-type keys. Turn-button operates springs. Also available as non-locking. Button may be red or black.

INDIVIDUAL PUSH KEY SWITCHES



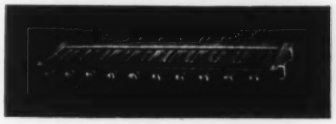
Require little space. May have 1 or 2 pile-ups with 5 springs each. Pushbutton cupped to fit finger-tips. Mounts on panels up to 1" thick. Red or black buttons.

"QUICK-ACTING" PUSH KEY SWITCHES



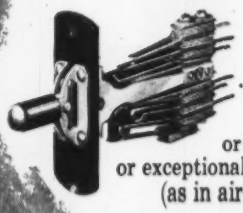
Operate on a roller, providing fast, free action. Push-button can be engraved with a one-digit number. Mounts on panels up to ¼".

COMPACT STRIPS OF PUSH KEY SWITCHES

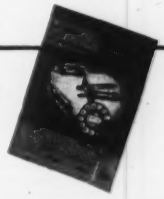


Provide groups of 10 or 20 switches in a very small space (11½" x ½" x 4"). Can be locking or non-locking. Buttons can be red, green or black.

Shock won't unlock the SHOK-LOK lever switch!



Designed to guard against the hazards of accidental or thoughtless tripping, or exceptional shock and vibration (as in aircraft use).



For key switch reference data, and a complete list of key switches and associated equipment for your applications, write for Catalog 4018.

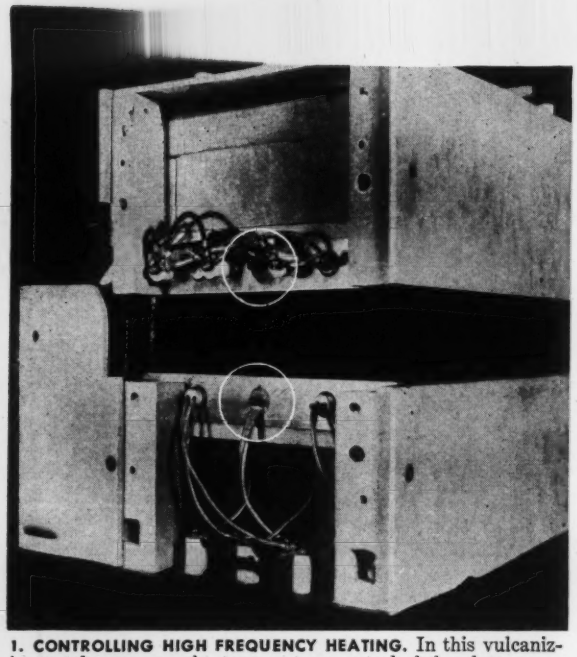
Address: Automatic Electric Sales Corporation, 1033 West Van Buren Street, Chicago 7, Illinois. (HAymarket 1-4300). *In Canada:* Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*

AUTOMATIC ELECTRIC

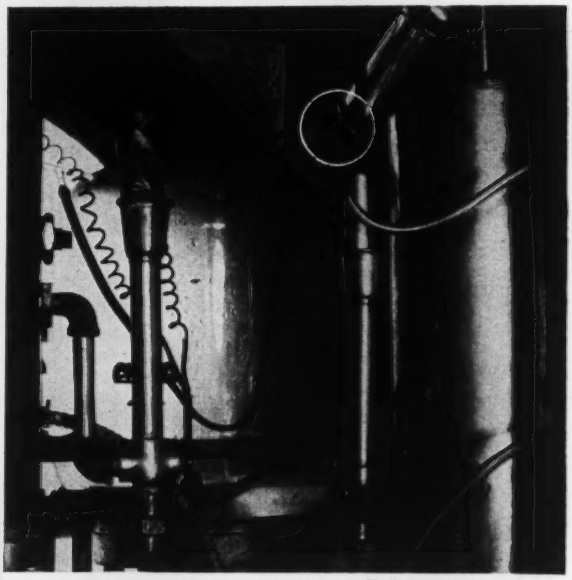
ORIGINATORS OF THE DIAL TELEPHONE

—ITEM 184—

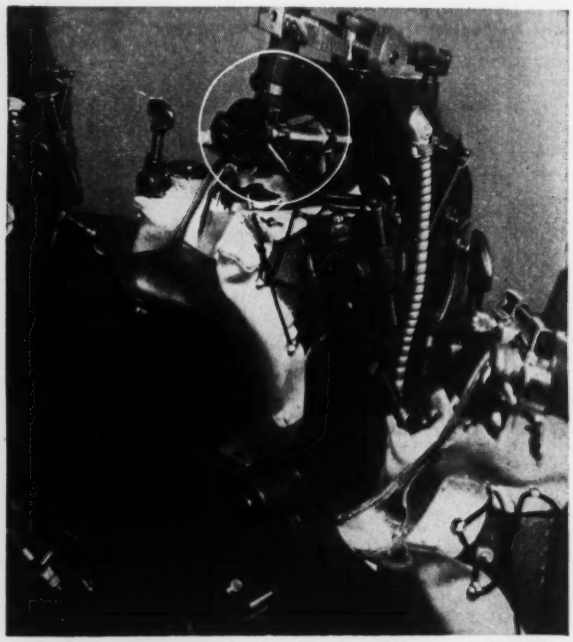
How would you solve these tricky temperature control problems?



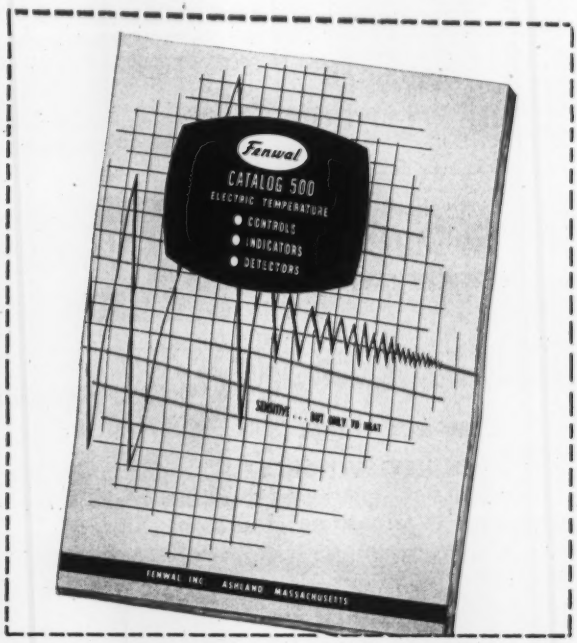
1. CONTROLLING HIGH FREQUENCY HEATING. In this vulcanizing patch press, precise temperature control of the platens was required to prevent loss of electronic heat generated within the processed material. Fenwal's solution was two THERMOSWITCH® units, set at 400F, mounted on the platens. Result: a production rate of 3,000 patches per hour, compared to ordinary hot press methods of 30 per hour.



2. SAFETY IN A DISTILLING PROCESS called for a dependable failure alarm. A Fenwal THERMOSWITCH unit in the condenser's safety vent solved the problem. Now, should the cold water supply fail, steam blowing through the condenser tubes will hit the THERMOSWITCH unit. This control, set at 120F, will then open, shutting off the electric heaters and sounding a continuous alarm.



3. PROTECTING PRODUCTS. In this shoe lining smoother, the problem was twofold: to use the fewest possible thermostats; provide close temperature control in order to prevent burning of shoe leather. Fenwal's solution: a single adjustable THERMOSWITCH unit, mounted on one ironer and controlling two ironers. This halved the number of thermostats indicated, while providing precision temperature control.



4. SEND FOR NEW CATALOG, just off the press. It describes Fenwal's complete line of THERMOSWITCH units and new indicating controllers for industrial applications. Fenwal engineers are always glad to help on any of your temperature control problems. Write **Fenwal Incorporated, 192 Pleasant St., Ashland, Massachusetts.**

Fenwal **THERMOSWITCH®**

Controls Temperature — Precisely

—ITEM 185—

For More Information Circle Item Number on Yellow Card—page 19

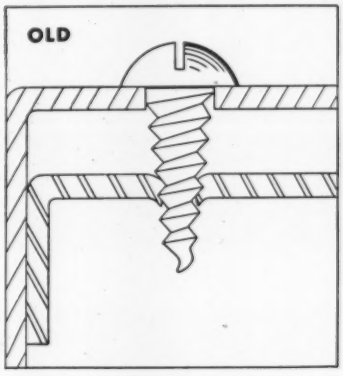
B.F. Goodrich Rivnut

provides shockproof nutplate, saves time and money

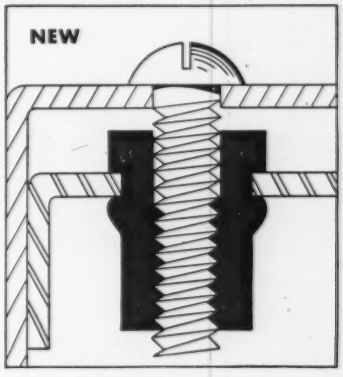
B. F. Goodrich Rivnuts provide accurate, shockproof nutplates in one, quick operation. They eliminate nuts, welding, tapping, clinching. They are particularly suited for blind applications where other methods of fastening are impossible. They give a tight, dependable seal. And save man-hours, too, because one operator can install a Rivnut in seconds.

Just as BFG Rivnuts speeded up output and eliminated assembly and service problems for the Graef Storm Window Co. (SEE PICTURES AT RIGHT), Rivnuts are uniquely successful when used in any thin sheet metal. They are the only method of fastening available that gives 6 clean threads for attachment. They can even be installed *after* enameling.

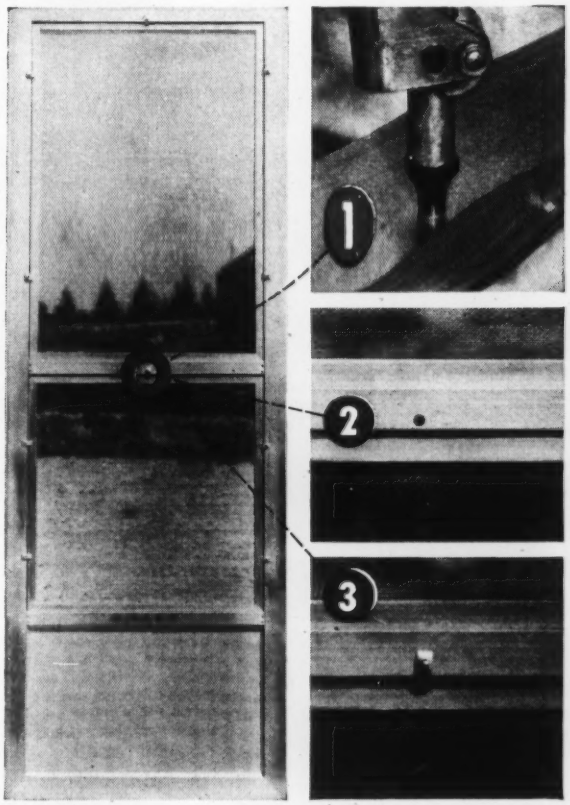
If you're looking for a fastener that can improve your product and cut production time, why not get the help of The B. F. Goodrich Co., Dept. MD-26, Akron, Ohio.



USING SELF-TAPPING SCREWS. To attach insert clips to aluminum storm doors, the Graef Storm Window Co. considered a conventional method, tried self-tapping metal screws. They found that due to the softness of the aluminum, screws pulled out and enlarged the hole. A new hole had to be made or a larger self-tapping screw used. They could foresee service problems. When storm windows were changed by the user, the metal would pull or tear.



USING B. F. GOODRICH RIVNUTS. No assembly problems, no service problems, reports Graef. Rivnuts speed assembly—installing in door stiles takes only seconds. They provide a firm, accurate nutplate that does not loosen with shock or vibration. At least 6 threads are clean for attachment, eliminating any pulling or tearing of metal during assembly or later, when storm windows are changed by the user.



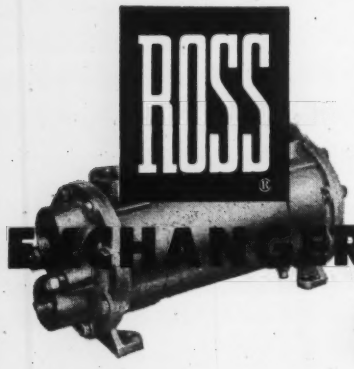
HOW GRAEF SPEEDS ASSEMBLY USING RIVNUTS
(1) Rivnut is inserted in blind aluminum door stile. Heading tool forms bulge inside in one, quick operation. (2) Rivnut fits smoothly, tightly. Six clean threads provide attachment for (3) bolt and retaining clip which holds screen insert. Door slamming, change of inserts will not loosen the nutplate the Rivnut provides.

Send now for FREE RIVNUT Demonstrator

Demonstrates with motion how you can use Rivnuts to fasten TO and fasten WITH. Explains construction, simplicity of installation. Get your free copy today by writing to: The B. F. Goodrich Company, Department MD-26, Akron, Ohio.

B.F. Goodrich RIVNUTS

The only one-piece blind rivet with threads



EXCHANGERS SPECIFIED FOR ENTIRE NEW LINE OF LAKE ERIE DIE CASTING MACHINES

Termed "expandable", Lake Erie's new Series D Die Casters have been introduced as simplified machines to which special features can be added as needed. Only *essentials for normal production are included.*

One of these *essentials* is a Ross Type BCF Exchanger. Hydraulic oil temperatures won't get out of hand to cause pump slippage here!

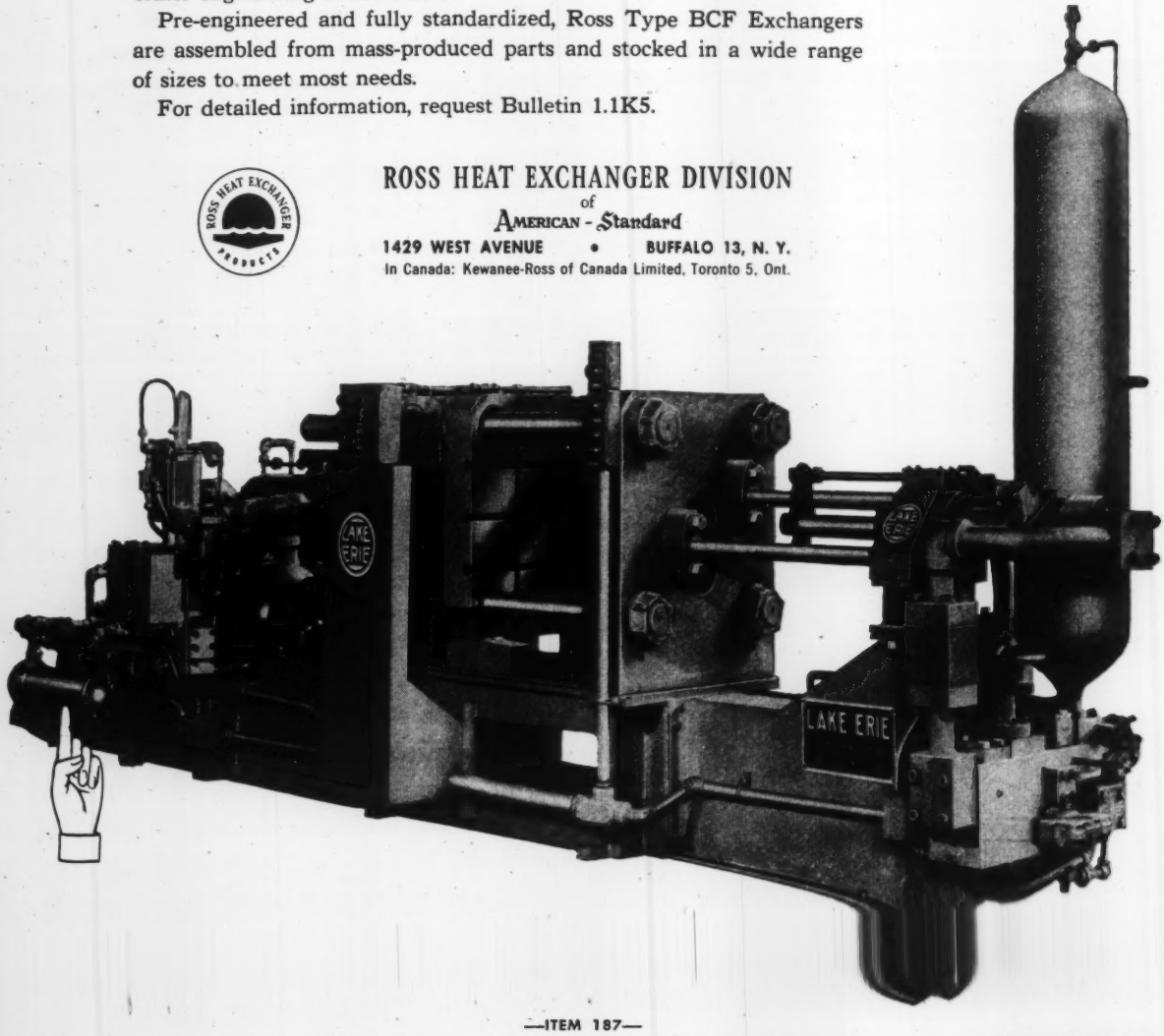
"In our effort to build an economical machine with rugged characteristics and top quality, it was only natural that we selected Ross oil coolers as part of the basic equipment," says Lake Erie Engineering Corporation.

Specifications for numerous types and makes of hydraulic machines regularly call for Ross Exchangers. In this way, top-rated thermal efficiency and ruggedness are both assured without costly "specials" in either engineering or fabrication.

Pre-engineered and fully standardized, Ross Type BCF Exchangers are assembled from mass-produced parts and stocked in a wide range of sizes to meet most needs.

For detailed information, request Bulletin 1.1K5.

ROSS HEAT EXCHANGER DIVISION
of
AMERICAN - Standard
1429 WEST AVENUE • BUFFALO 13, N. Y.
In Canada: Kewanee-Ross of Canada Limited, Toronto 5, Ont.



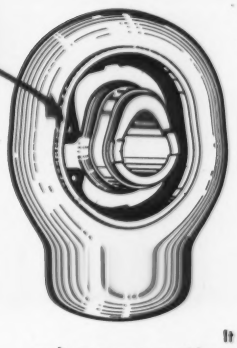
—ITEM 187—

Waldes Truarc Retaining Rings Eliminate Machining—

Provide Stronger Assembly, Greater Accuracy

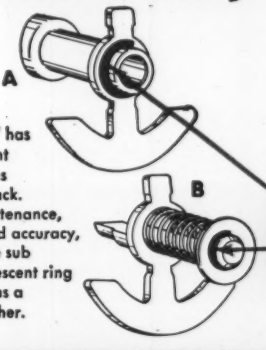
The American Hardware Corp., New Britain, Conn., uses 4 different types of Waldes Truarc Retaining Rings in the original design of these famous Corbin and Russwin Heavy Duty Cylindrical Locks. Truarc rings improve product performance, eliminate rejects, and cut labor costs.

Knob Sub Assembly



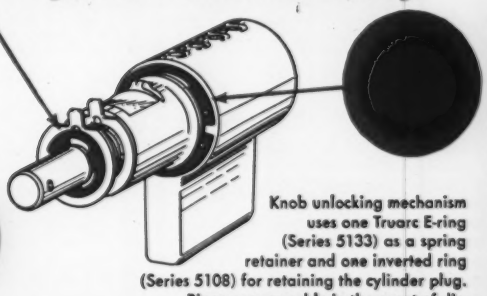
Truarc Beveled Ring (Series 5002) couples the knob to the knob shank. It eliminates two tapped holes and two screws, provides stronger assembly and greater accuracy. Beveled ring takes up end play rigidly.

Spindle Sub Assembly



Spindle sub assembly "A" has two Waldes Truarc crescent rings (Series 5103) used as locating flanges for rollback. This saves labor and maintenance, improves performance and accuracy, eliminates rejects. Spindle sub assembly "B" uses one crescent ring as a spring retainer and as a locating shoulder for washer.

Cylinder Sub Assembly



Knob unlocking mechanism uses one Truarc E-ring (Series 5133) as a spring retainer and one inverted ring (Series 5108) for retaining the cylinder plug. Rings are re-usable in the event of disassembly for maintenance. Rejects are eliminated.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product...to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types...as many as 97 different sizes within a type...5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U.S.A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.

For precision internal grooving and undercutting...Waldes Truarc Grooving Tool!

Send for new catalog supplement

WALDES

TRUARC®

RETAINING RINGS

Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N. Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

*Name*_____

*Title*_____

*Company*_____

*Business Address*_____

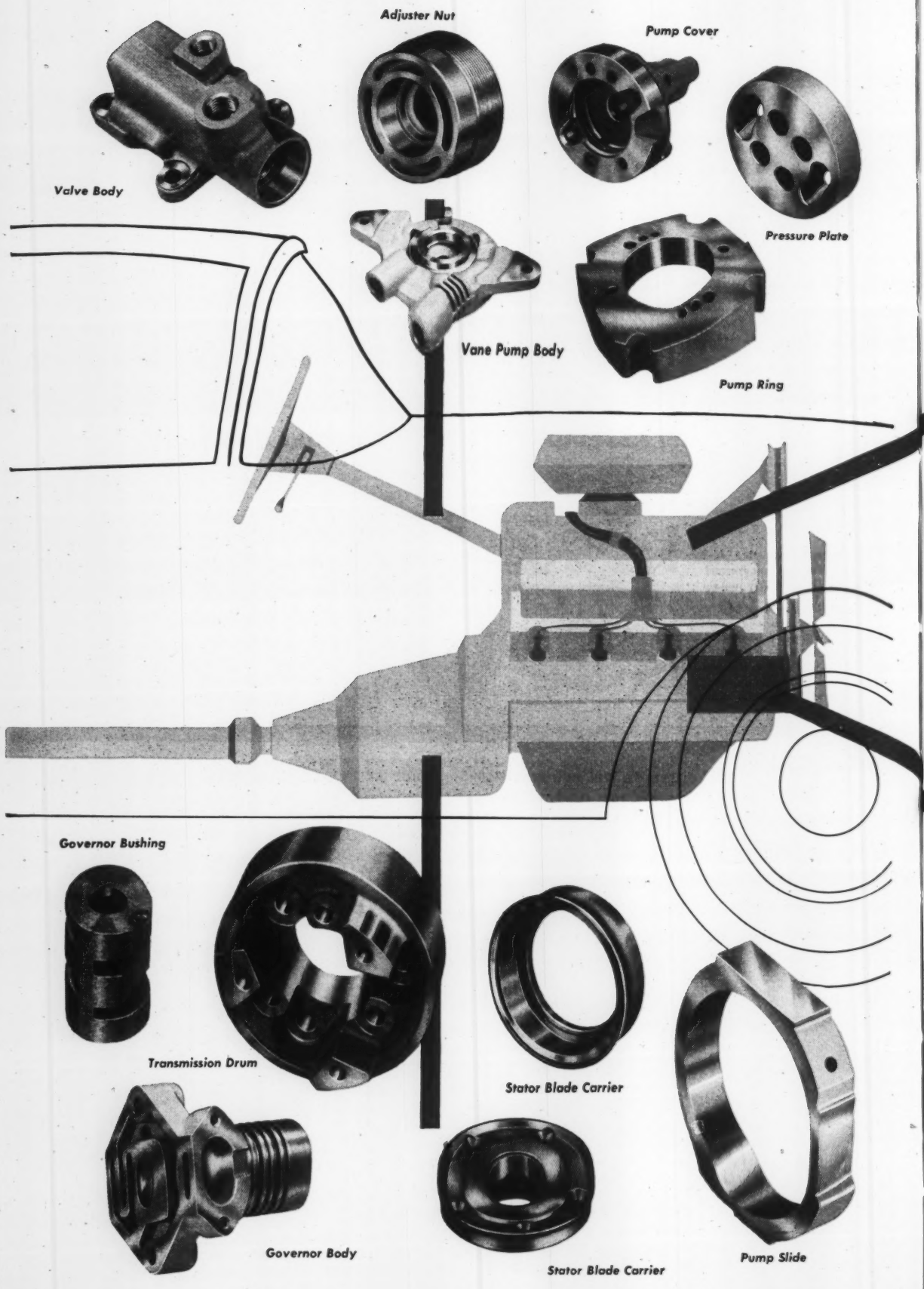
*City*_____ *Zone*____ *State*_____

MD028

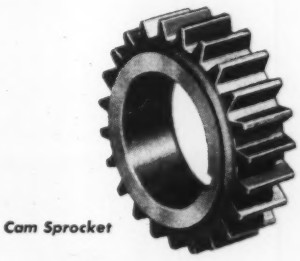
WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

—ITEM 188—

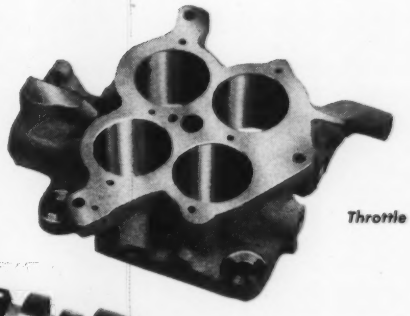
CENTRAL FOUNDRY SHELL



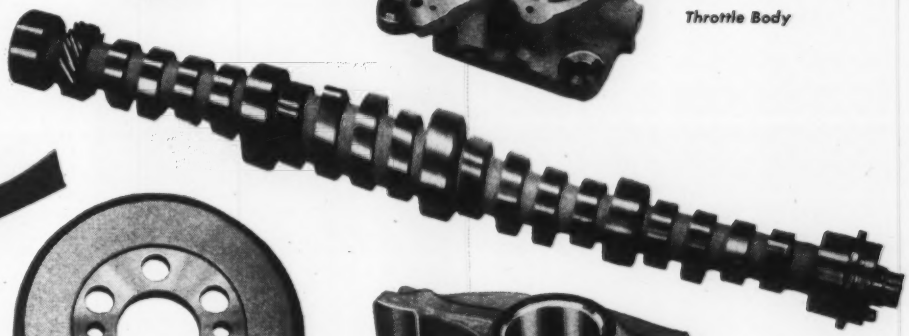
CASTINGS in the 1956 automobiles



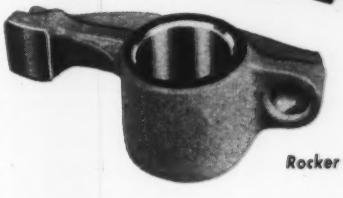
Cam Sprocket



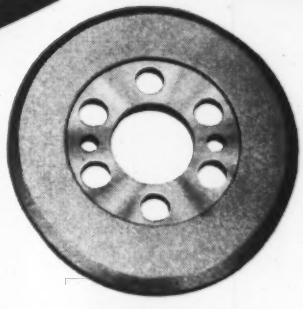
Throttle Body



Camshaft

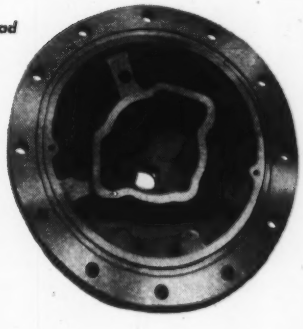


Rocker Arm



Harmonic Balance Weight

Compressor Head



Balance Weight

In the steering mechanism, in the transmission, in the air conditioning compressor, and throughout the engine, most of America's fine new 1956 automobiles depend on Central Foundry Division shell castings. Shell castings—produced by the newest of ferrous molding techniques—has resulted in improved products and reduced machining costs to these auto manufacturers. The greater accuracy of the thin shell mold enables Central Foundry Division to cast parts to closer tolerances, thus reducing machining time, and also to cast difficult sections that would be impractical with other ferrous molding methods. Parts that are shell-cast of grey iron, malleable iron, and ArmaSteel in large production quantities by Central Foundry Division, offer advantages of uniformity in many applications . . . they may help your product, too. For further information about our shell casting process, write for descriptive literature . . . or request personal help from our experienced engineers, without obligation.

CENTRAL FOUNDRY DIVISION · GENERAL MOTORS CORPORATION

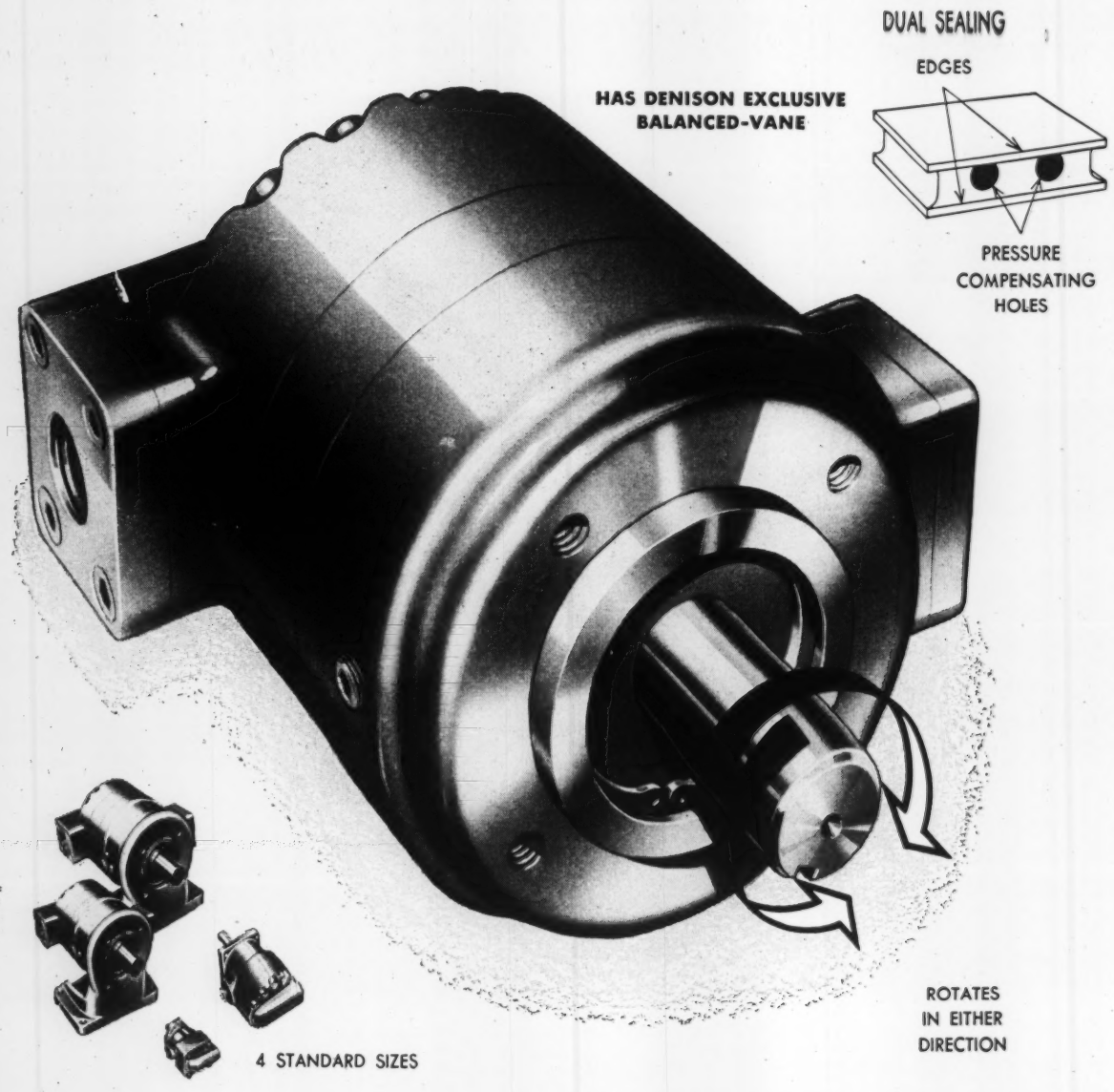
CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION

SAGINAW, MICHIGAN • DEPT. 14

57

—ITEM 189—



for continuous 2000 psi service...

Vane type Denison hydraulic single stage, Pump/Motor

IT'S A PUMP—high delivery in a small, compact package . . . a continuous 2000 psi pump.

IT'S A MOTOR—high stalled torque up to 257 pound-inches per 100 psi. Takes high shock pressures without danger.

EXCLUSIVE—Denison *Radially Balanced* Vane; *Cuts wear* between cam ring and vane; *Increases efficiency* with dual sealing edges; *Reduces pulsation* by radial pumping action of vanes.

SIMPLIFIES INVENTORY

No need to stock separate pumps and motors. Runs as a pump or motor without alterations. Range of capacities in each size through interchangeable cam rings.

EITHER DIRECTION—Operates efficiently as a pump or motor without change in piping. Minimum internal friction in either direction because of greatly reduced contact pressure between vanes and cam ring.

STANDARD SIZES—as a pump, Range of delivery 2.5 to 77 gallons per minute at 2000 psi.
As a motor, Horsepower output 1 to 103 hp at 2000 psi.

MORE INFORMATION—Send for Bulletin P-5-A giving complete specifications. Write . . .

THE DENISON ENGINEERING COMPANY
1240 Dublin Road • Columbus 16, Ohio
A Subsidiary of American Brake Shoe Co.

DENISON Hydr OIL ics

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

—ITEM 190—

Slotted tubes extruded from BAKELITE Polyethylene by **Jessall Plastics, Inc.**, Kensington, Conn.
for the Exide Industrial Division of The Electric Storage Battery Company, Philadelphia 2, Pa.

Corrosion-Resistant Polyethylene Parts Boost Battery Power, Working Life

The new "Exide" "Ironclad" battery was developed for heavy-duty service . . . for example, powering of lift trucks. It's got the usual dimensions, but it's a bigger battery. According to the manufacturer, it packs 20 per cent more power . . . delivers 100 per cent capacity initially (not the ordinary 85) . . . and its working life is longer than that of earlier models.

New design and a new material made it possible. Finely slotted tubes extruded from BAKELITE Brand Polyethylene hold the active material of the positive plates. They permit maximum exposure to the electrolyte. And being BAKELITE Polyethylene, they don't corrode and shorten battery life. To complete the picture, the bottoms of the tubes are closed with sealers molded from BAKELITE Polyethylene.

Corrosion resistance is just one important advantage of BAKELITE Polyethylene. This material is readily molded or extruded into finely detailed shapes. It is the lightest commercial plastic. Dielectric properties are outstanding. It is supplied in a wide range of colors.

The properties of BAKELITE Polyethylene may be important to your product planning. For more information, write Dept. LC-103.

BAKELITE BRAND Polyethylene Plastic

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.
In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario
The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC

—ITEM 191—

FORD INSTRUMENT

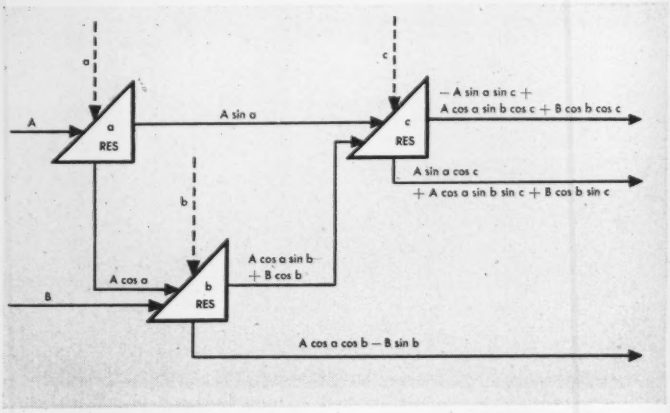
solved one design problem by

CASCADING RESOLVERS WITHOUT ISOLATION AMPLIFIERS

To get around a problem that arises in almost every resolver application Ford engineers recently designed a computer which, among other things, employed a chain of cascaded resolvers to solve complex trigonometric equations, without the use of isolation amplifiers. They solved such an equation as:

$$A \sin a \cos c + A \cos a \sin b \sin c + B \cos b \sin c$$

This was successfully done, without use of vacuum tubes or amplifiers in this circuit:



In view of the widespread use of resolvers to generate sine and cosine functions in modern electro-mechanical analogue computers, it is of great practical significance. Resolvers produced by the Ford Instrument Company have now reached such a high degree of precision, that it is possible to obtain, from an unloaded resolver (which accommodates a single angular quantity only), an accuracy to within less than one tenth of one percent. But most computing circuits call for the use of several resolvers, and once an ordinary resolver is loaded by another resolver, no matter how high its precision, the overall accuracy of the resolver cascade is seriously affected.

The conventional method of avoiding this difficulty is to use an isolation amplifier for each resolver, so that the resolver continues to operate under no-load conditions regardless of the size of the cascade. The importance of cascading without amplifiers is readily appreciated if we realize that the isolation amplifier usually increases the cost of the equipment, more than doubles the size and generates many times more heat that must be dissipated to prevent breakdown of the components. Furthermore, the use of vacuum-tube amplifiers always raises the problem of tube ruggedness and reliability, and requires an additional source of d-c plate voltage.

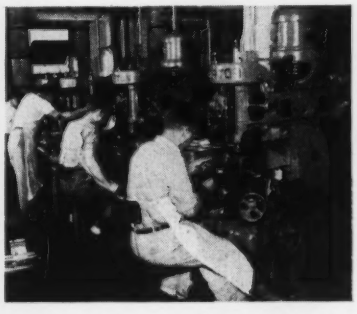
Have you problems which the engineers at Ford might solve by designing and manufacturing computers, controls or their elements? Write for further information.

85

FORD INSTRUMENT COMPANY
Division of Sperry Rand Corporation
31-10 Thomson Ave., Long Island City 1, N. Y.

Ford's capabilities are among the finest in the country

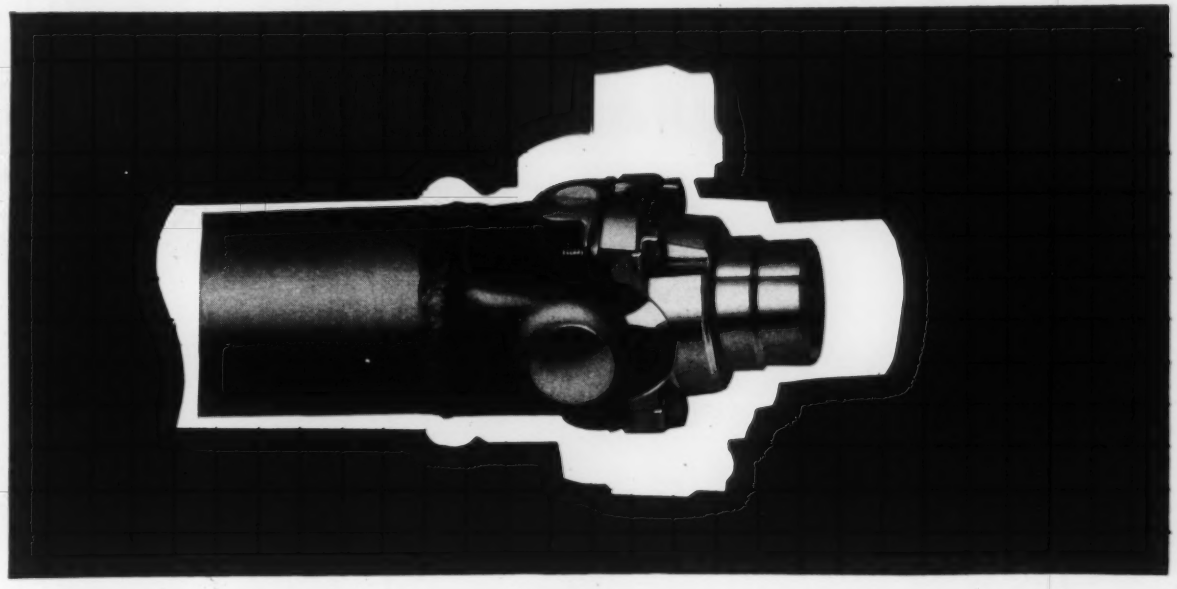
One of the Ford laboratories where a particular design project has called for careful study of resolvers and resolver cascading. Two of the engineers assigned to this project are here checking results. From this work will come one of the new, highly classified weapon systems for the armed forces.



For accuracy and reliability—both vitally necessary in military instruments—experienced machinists must work to fine precision—in the order of .0005 of an inch. Here in one section of the shops of Ford Instrument Company, men are milling parts for an airborne computer.

During the past year Ford Instrument Company has been busy working on many contracts for the U. S. Air Force and the U. S. Navy Bureau of Aeronautics, designing and manufacturing complex computers, controls and their components. For over forty years, Ford Instrument Company has devoted most of its efforts in working for the government to the many problems of weapon controls.

FOUR WAYS BETTER



1. STRONGER—2500 lbs. Ft. static torque. This NEW joint is stronger than any previous automobile joint of comparable size.

2. SMALLER—3-9/16" swing diameter. This NEW joint requires less clearance, making possible more compact design.

3. LIGHTER—This NEW joint weighs 20% less than previous joints having the same torque capacity.

4. EASIER TO INSTALL—This NEW joint saves time and money on the assembly line because it has less parts to handle.

Give your next car the benefit of the 4 advantages provided by this NEW joint development. Let MECHANICS engineers help you design power transmission lines better suited to the low floor board, more powerful engine and higher speed requirements of your future models. Send print and specifications—for their prompt recommendations.

MECHANICS UNIVERSAL JOINT DIVISION

Borg-Warner • 2032 Harrison Ave., Rockford, Ill.

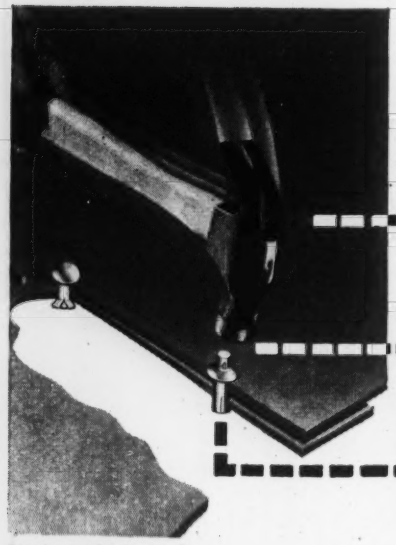
MECHANICS

Roller Bearing BW

UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

only SOUTHCO® drive rivets offer all these benefits!



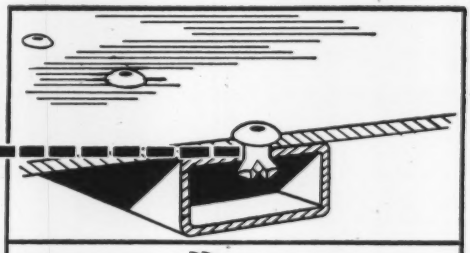
Rivet and Mfg. Patented.

A HAMMER IS THE ONLY TOOL

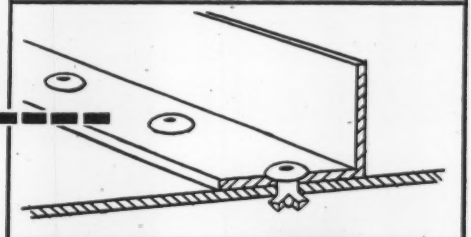
DRIVE LIKE NAILS

AUTOMATIC "PULL-UP" ACTION FORCES PARTS TOGETHER

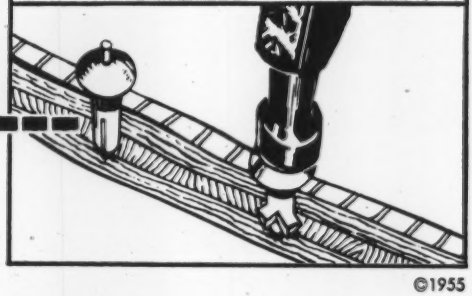
FOR BLIND APPLICATIONS



FOR ACCESS APPLICATIONS



FOR METAL-TO-WOOD APPLICATIONS



Note

No special tools to buy or maintain, no bucking up, no finishing, no noise, no material waste.

Just hit the pin, the rivet's in . . . that's all.

On your production line, where can savings be made with Southco Drive Rivets? Write for complete data. Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

SPEED ASSEMBLY . . . CUT COSTS

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SOUTHCO®

FASTENERS

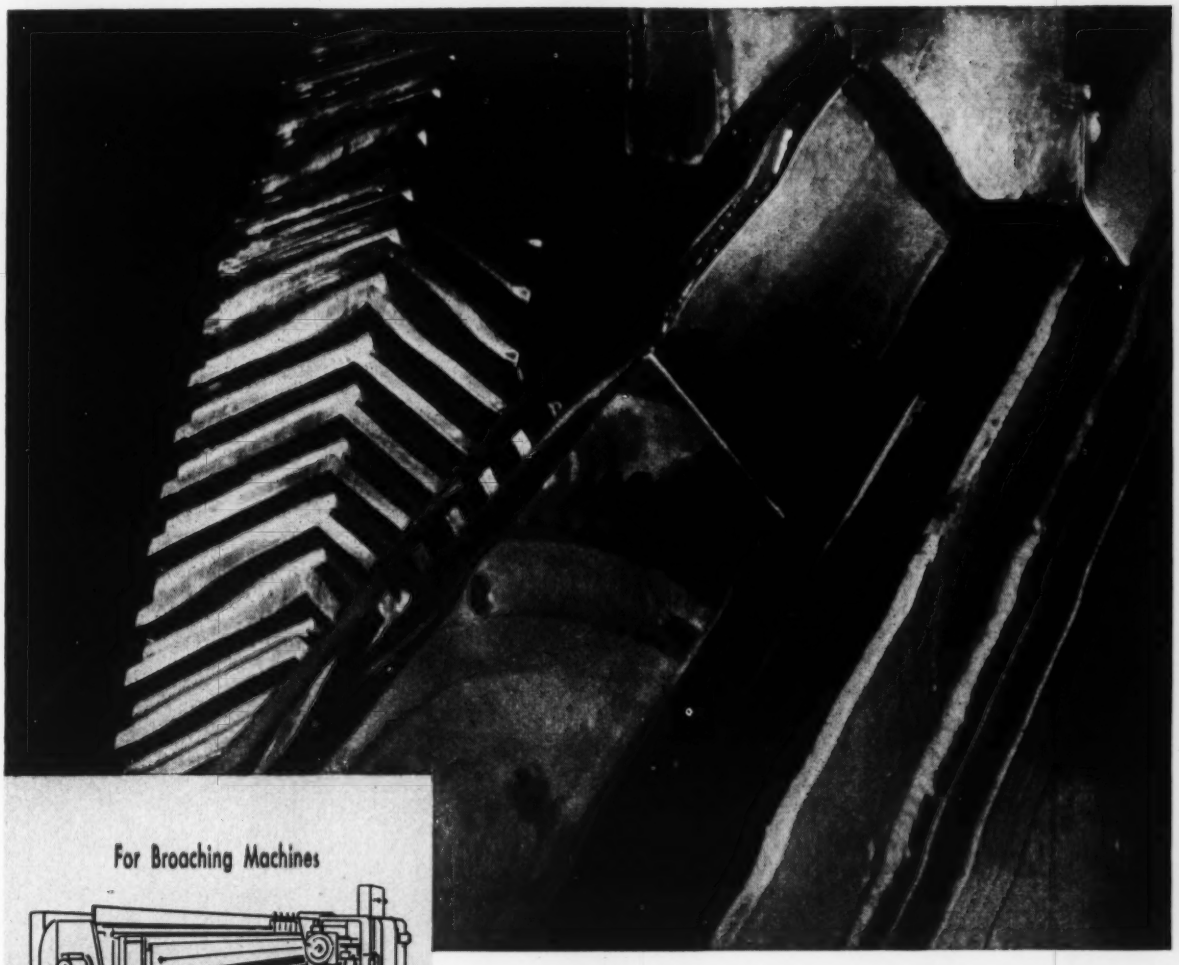
PAWL • SCREW AND SPRING • DRIVE RIVETS • ANCHOR NUTS • ENGINEERED SPECIALTIES

OFFICES IN PRINCIPAL CITIES

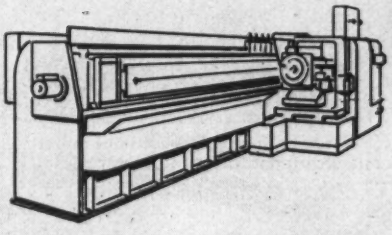
WHEREVER TWO OR MORE PARTS ARE FASTENED TOGETHER; STANDARD AND SPECIAL DESIGNS FOR IMPROVED PERFORMANCE AND LOWER PRODUCTION COSTS

—ITEM 194—

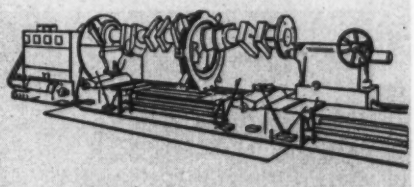
For More Information Circle Item Number on Yellow Card—page 19



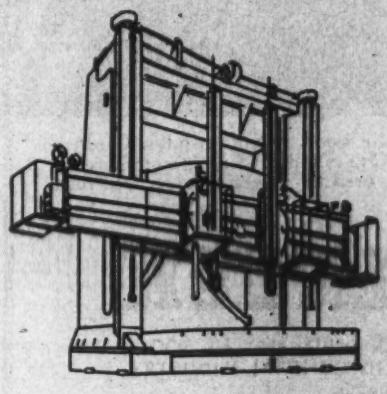
For Broaching Machines



For Heavy-Duty Lathes



For Boring Mills



. . . and for many other applications

BENEFITS OF BACKBONE

for machine-tool applications

The backbone in Farrel® herringbone gears, formed by the meeting of the two helices without a center groove, puts the *entire* face width of the gear to work. Benefit: Higher load-carrying capacity in less space—especially important in machine-tool applications. The opposed helices balance and absorb axial thrust within the gear member, preventing harmful thrust load with consequent stresses on other parts of the machinery.

The Farrel-Sykes method of gear generation assures extreme accuracy of tooth spacing, contour and helix angle. Benefit: Smooth, uniform power flow. Backlash is reduced to a minimum and the load is distributed evenly across the entire face width.

If you have a gear problem let us hear about it. Benefit: The assistance of engineers experienced in the design of gears for a wide variety of machine-tool applications.

FARREL-BIRMINGHAM COMPANY, INC., ANSONIA, CONN.

Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.

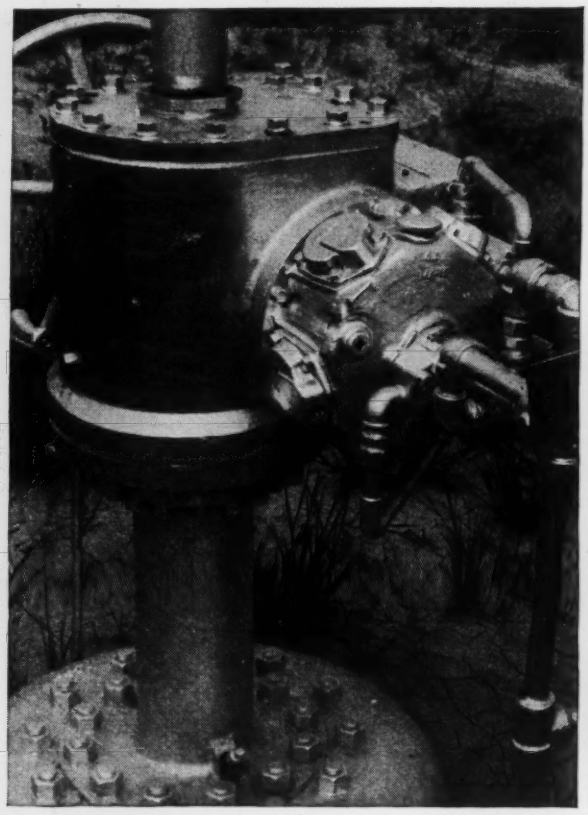
Sales Offices: Ansonia, Buffalo, New York, Boston, Akron, Detroit, Chicago, Memphis, Minnesota, Fayetteville (N. C.), Los Angeles, Salt Lake City, Tulsa, Houston, New Orleans

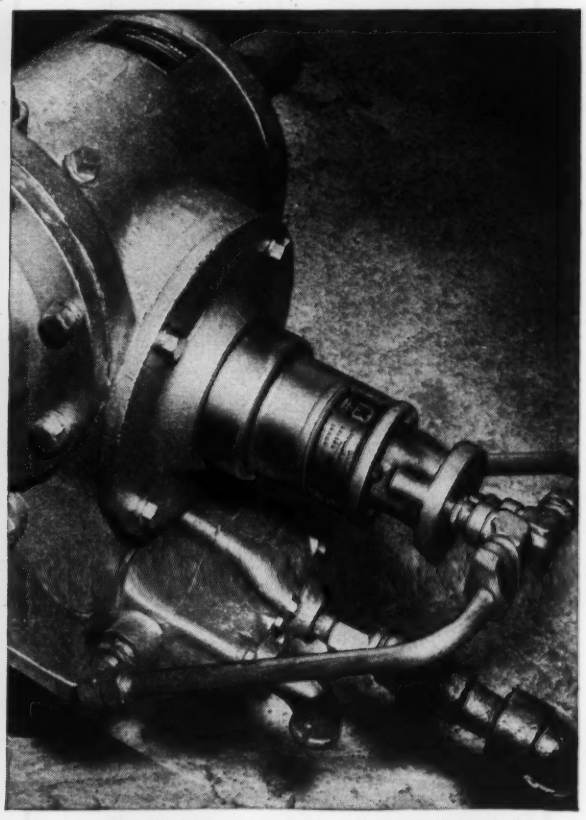
Farrel-Birmingham®

FB-1030

—ITEM 195—

Gardner-Denver... Serving the World's Basic Industries





Safe, remote control of natural gas lines, using air motors to operate valves. Left: Gardner-Denver five-cylinder radial air motor on 24" valve. Right: Keller Tool axial piston air motor. Both motors operate on natural gas at line pressure.

No fire hazard with these air motors

Think of air motors when the specs call for rotary power in gassy, dusty, fire hazardous spots. Air motors can't spark. They won't burn out when overloaded—merely stall. They don't heat up under constant starting, stopping, reversing.

And when you think of air motors, remember Gardner-Denver and Keller Tool offer a complete line of *quality* air motors from ½ hp to 16 hp. Five-cylinder radial, axial piston, and rotary vane types. Send for descriptive bulletins.

Midst the wood dust of sawmills, Gardner-Denver five-cylinder radial air motors are frequently used for powering edger feed rolls.

GARDNER - DENVER

THE QUALITY LEADER IN COMPRESSORS, PUMPS, ROCK DRILLS AND AIR TOOLS FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

—ITEM 196—

For More Information Circle Item Number on Yellow Card—page 19

DELIVERY OFF THE SHELF

IN **64,000** COMBINATIONS

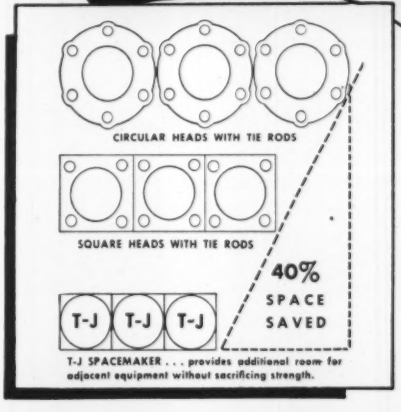
T-J

Spacemaker CYLINDERS

OUTMODE ALL OTHERS . . . SAVE 40% SPACE!

You'll never go back to tie-rod cylinders, once you apply T-J Spacemakers to your push-pull-lift jobs! Advantages in space saved, weight saved, greater strength and off-the-shelf delivery are among the dozens of Extras you get as Standard!

Now — these sensationally popular T-J Spacemaker Cylinders are available off the shelf *in sizes up to 8″*. This means as many as 64,000 different combinations of styles, bores, strokes, mountings, etc. *immediately available!* Oil pressure to 750—Air to 200 P.S.I. Super Cushion Flexible Seals for Air . . . New Self-Aligning Master Oil Cushion. Hard chrome plated bodies and piston rods (Standard). Only from T-J can you get these new ingenious cushion designs! Send for bulletin SM-155-2. The Tomkins-Johnson Co., Jackson, Mich.


CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
40% SPACE SAVED
T-J
T-J
T-J
T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

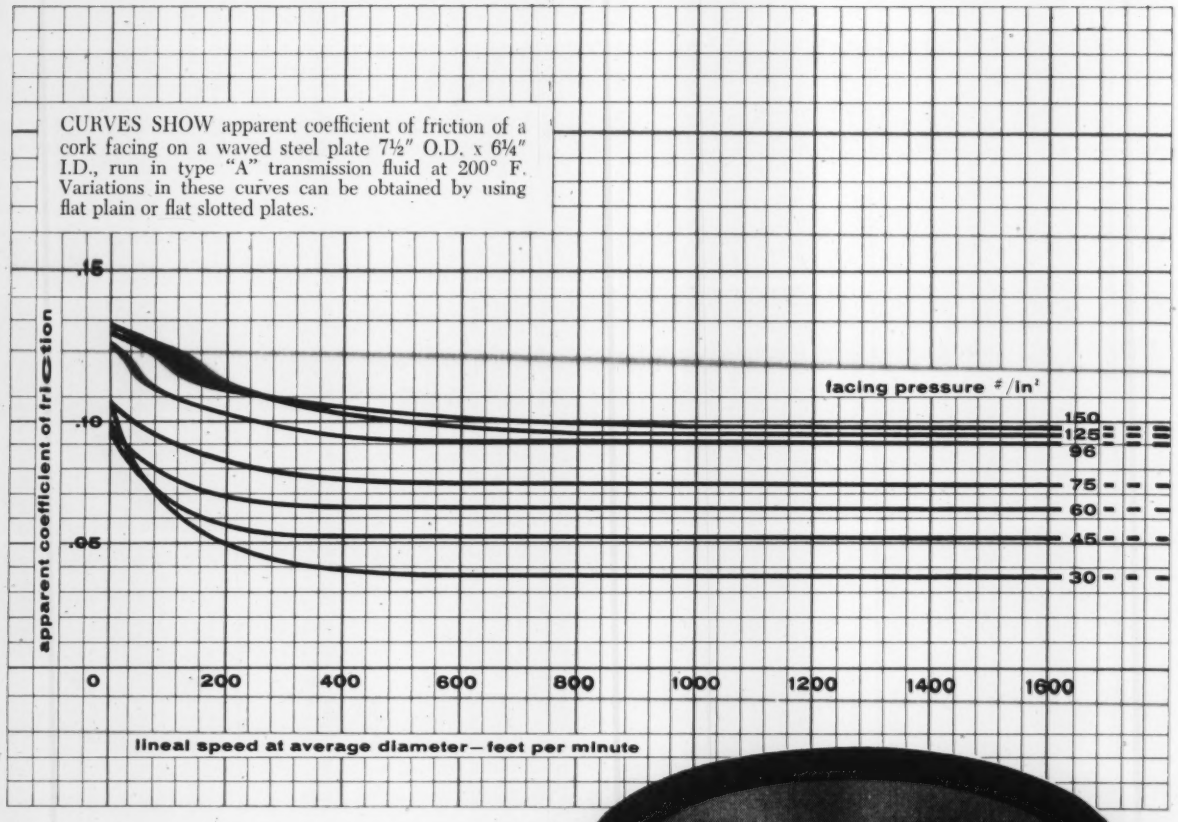
See us in Fluid Power Area ASTE Show Booth 225

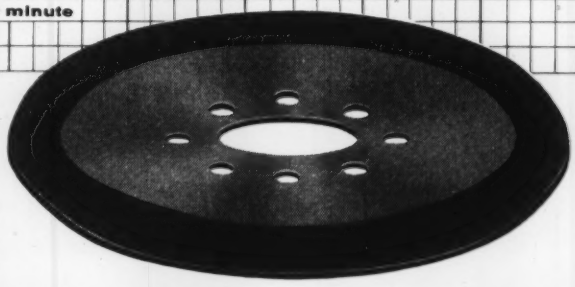
Member of the National Fluid Power Association

T-J TOMKINS-JOHNSON

RIVITORS . . AIR AND HYDRAULIC CYLINDERS . CUTTERS . CLINCHORS

—ITEM 197—





CORK CLUTCH FACINGS:

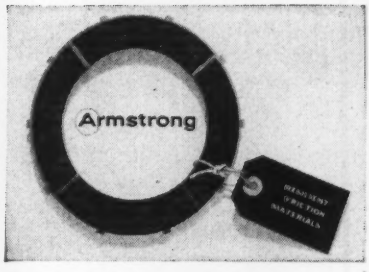
How a waved plate affects engagement characteristics

Two of cork's unique advantages as a friction material are its flexibility and its unusually high coefficient of friction when immersed in oil. These two characteristics contribute much toward the wide latitude cork compounds offer designers in wet clutch applications.

For example, by using cork facings on waved plates the designer can control and manipulate the oil film—and thus produce a soft, gradual engagement when desired.

At low pressures, cork facings on waved steel plates apparently ride on the oil film like a Kingsbury Thrust Bearing. As pressure is increased, however, the waved plate flattens—and better contact is made. When maximum pressure is developed, the plate flattens to make full contact, and engagement is completed.

Still other engagement characteristics can be obtained by using a cork facing on a flat steel plate, or by slotting a cork facing, or by varying engagement pressures. Additional data on this subject—along with many helpful charts and graphs—is contained in the booklet shown at the right.



NEW 16-PAGE BOOKLET

For more information on the design versatility of cork-compound friction materials, send for a copy of our new booklet, "Armstrong Resilient Friction Materials." Write to Armstrong Cork Company, Industrial Division, 7202 Dean Street, Lancaster, Pennsylvania.

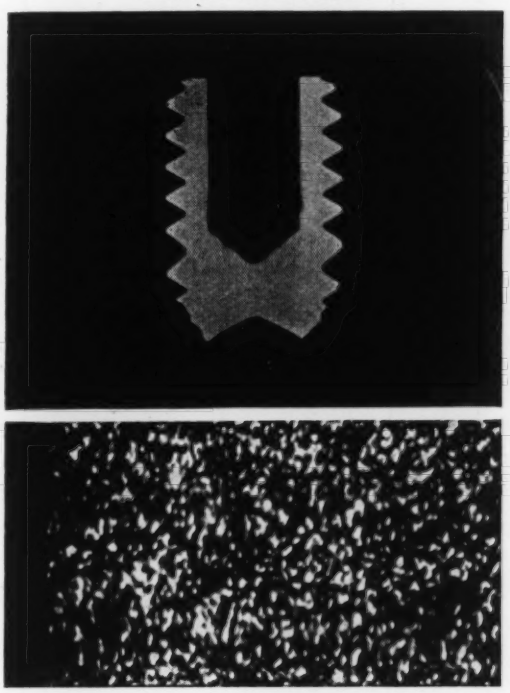
Armstrong FRICTION MATERIALS

. . . used wherever performance counts

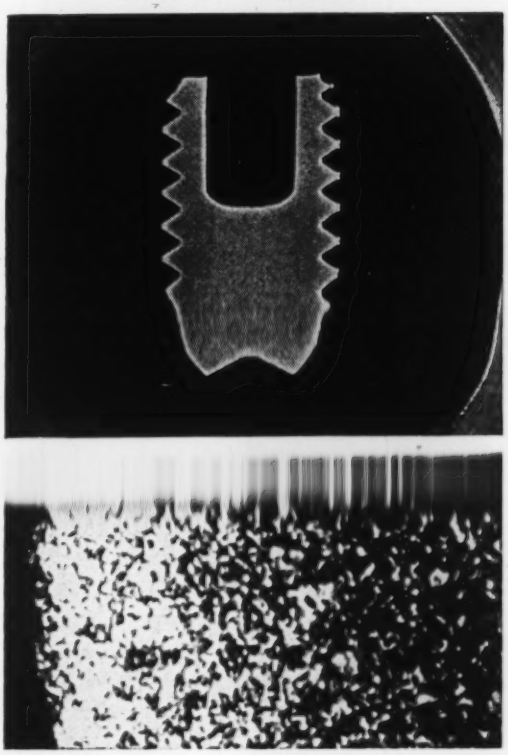
—ITEM 198—

New heat-treatment methods help High-Torque Unbrako socket set screws withstand up to 40% Higher Torques

UNBRAKO SET SCREW



ORDINARY SET SCREW



—you can set them and forget them

Research had proved that the tighter you seat a set screw the better it works. So we developed a set screw that could be tightened tighter than ever before without damaging the screw. One of the problems was developing new methods of heat treatment to eliminate decarburization. Decarb of course plays havoc with a screw. Put a wrench in the socket and you ream it. Run the screw into a tapped hole and you strip its threads. Try to seat it and its point shears off. These photographs are a study in contrasts. The UNBRAKO is clean, its grain uniform. There is no decarburization —the ordinary set screw is suffering from an overdose of it, socket walls, threads and point are full of the telltale white spots.

You can't buy a better screw than an UNBRAKO. And you can't get full *high-torque* performance without a "High-Titan" UNBRAKO Hex Key—the high-ductility, precision internal wrenching tool. See your industrial distributor. Or write STANDARD PRESSED STEEL Co., Jenkintown 18, Pa.

RECOMMENDED SOCKET SET SCREW TIGHTENING TORQUES (Inch-Pounds)

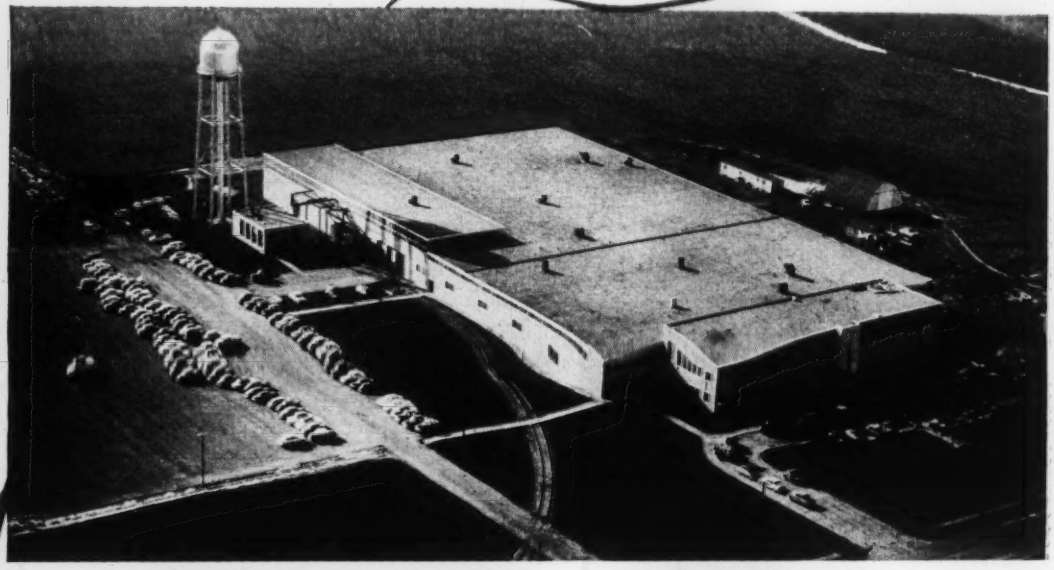
SCREW SIZE	UNBRAKO	SET SCREW B	SET SCREW C	MINIMUM DIFFERENTIAL %
#4	5	3.9	3.5	28
#5	9	7.8	7.4	15
#6	9	7.8	7.4	15
#8	20	14.7	14.5	36
#10	33	26.5	25	25
1/4	87	62	60	40
5/16	165	122	125	32
3/8	290	198	225	29
7/16	430	309	350	23
1/2	620	460	500	24
5/8	1225	1106	1060	11
3/4	2125	1540	1800	18
7/8	5000	3660	4600	9
1	7000	5025	6500	8

STANDARD PRESSED STEEL CO.

UNBRAKO SOCKET SCREW DIVISION SPS JENKINTOWN PENNSYLVANIA

—ITEM 199—

a *NEW* Division of
THE NEW YORK AIR BRAKE COMPANY
Brings Together, in a Single Unit, All Operations of DUDCO® and HYDRECO®



HYDRECO®
GEAR-TYPE PUMPS AND MOTORS CONTROL VALVES AND CYLINDERS

DUDCO®
DUAL-VANE HYDRAULIC PUMPS AND FLUID MOTORS

This new plant, tooled with the very latest precision production and test equipment, assures for you the HYDRECO and DUDCO Hydraulic components you need when you need them.

Here are complete facilities for the development and manufacture of modern industrial Hydraulic products . . . expanded engineering . . . high precision production machinery . . . increased capacity . . . all devoted exclusively to the manufacture of DUDCO and HYDRECO products.

Write for catalogs today.

KALAMAZOO DIVISION
THE NEW YORK AIR BRAKE COMPANY

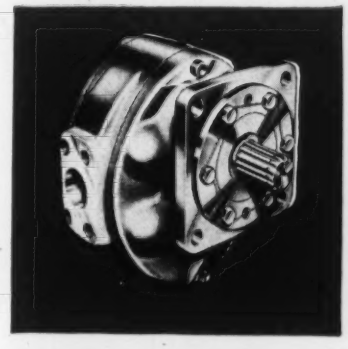
KALAMAZOO • MICHIGAN

INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

Now • • • FROM KALAMAZOO
HYDRECO® and DUDCO®
FLUID POWER COMPONENTS
for
ALL TYPES of MOBILE EQUIPMENT
and GENERAL INDUSTRIAL APPLICATIONS

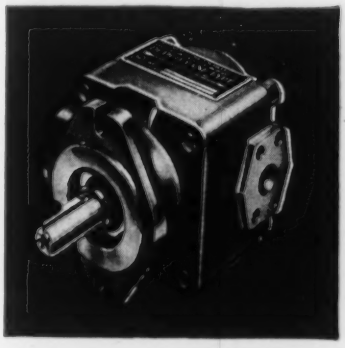
HYDRECO
HYDRAULIC PUMPS

Famous Four-Bolt design, Gear-type Pumps for 1000 and 1500 psi operation in sizes delivering 3 to 110 gpm at 1200 rpm. Also available in Dual and Tandem units.



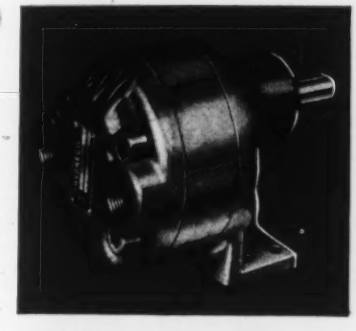
DUDCO
DUAL-VANE PUMPS

Fully balanced Dual-Vane Pumps for 2000 psi Continuous Operation in sizes 1½ to 120 gpm for heavy duty mobile and machine tool applications.



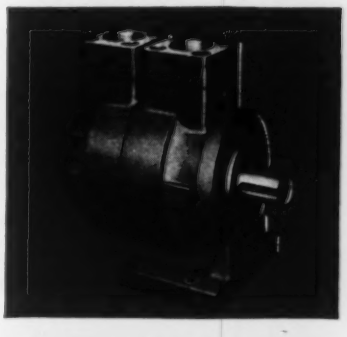
HYDRECO
FLUID MOTORS

Gear-type Motors in the famous HYDRECO Four-Bolt design featuring high running torques and operating at 1000 and 1500 psi. Flange or foot mounted models developing 0.1 to 60 hp.



DUDCO
FLUID MOTORS

Over 30 standard models for 2000 psi Continuous Operation, torque output from 180 to 14,400 lb.-in. Continuous Running Speeds to 3600 rpm.

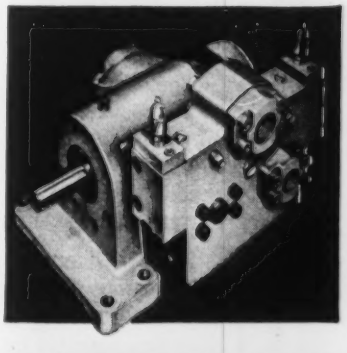


HYDRECO
HYDRAULIC VALVES

Hollow-Plunger Control Valves with 1 to 6 Plungers in capacities from 5 to 100 gpm for operating pressures of 1500 psi.

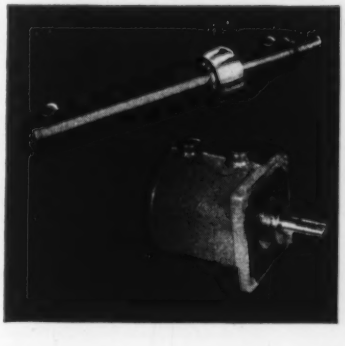
DUDCO
DOUBLE PUMPS

Equipped with Valve Panels. DUDCO Double Pumps provide simple and inexpensive Two-Pressure systems for Machine Tools and Hydraulic Presses.



HYDRECO
HYDRAULIC CYLINDERS

Custom built Telescopic, Single-Acting and Double-Acting Cylinders designed to conform to special requirements for all types of mobile equipment.



HYDRECO
AUXILIARY VALVES

Adjustable Pressure Relief, Pilot Operated Checks and Selector Valves, as well as many Special Purpose Valves in capacities to 100 gpm and 2000 psi.

Engineered by Tinnerman...

NEW SNAP-ON MOTOR CLIP REPLACES 4 PARTS

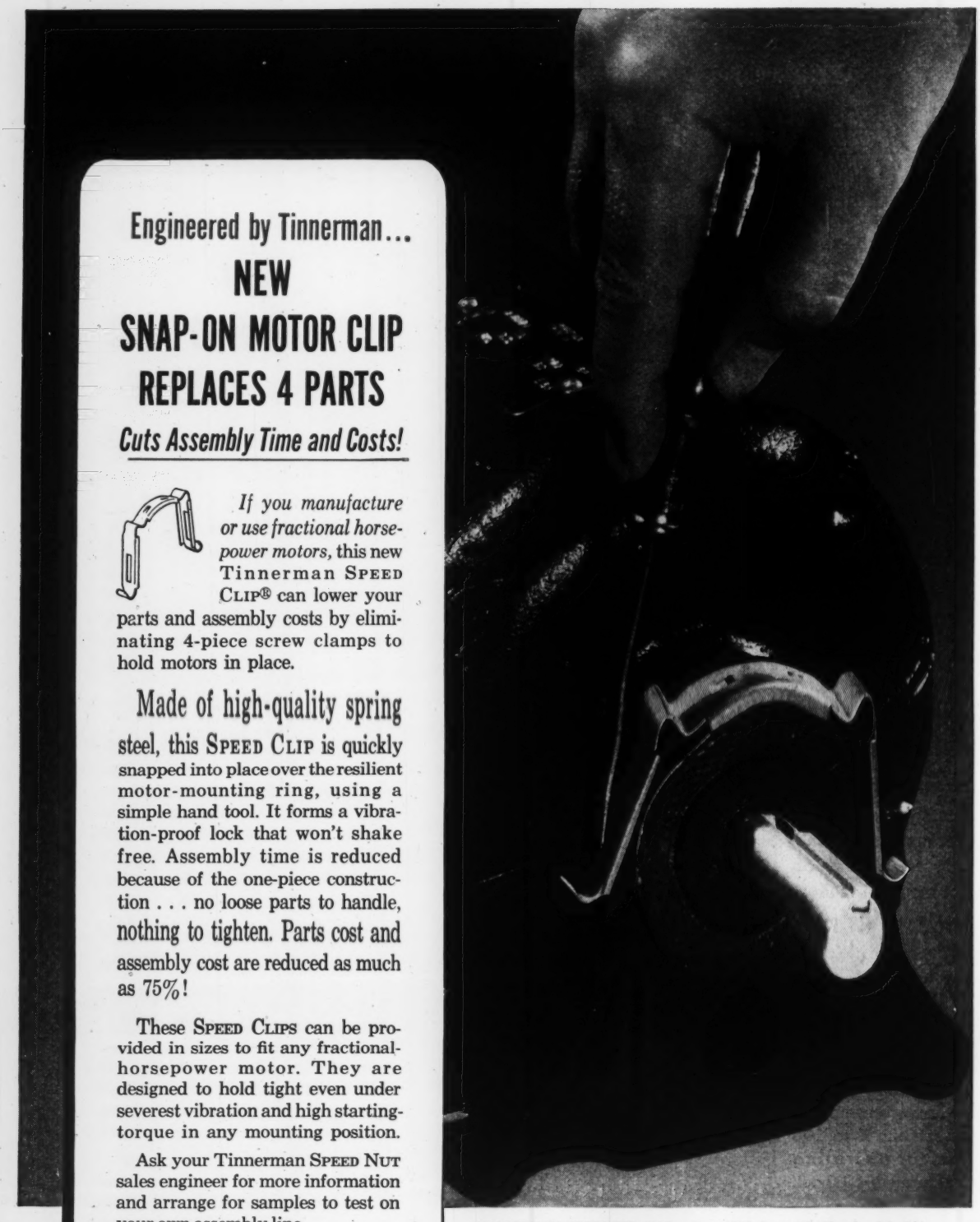
Cuts Assembly Time and Costs!

If you manufacture or use fractional horsepower motors, this new Tinnerman SPEED CLIP® can lower your parts and assembly costs by eliminating 4-piece screw clamps to hold motors in place.

Made of high-quality spring steel, this SPEED CLIP is quickly snapped into place over the resilient motor-mounting ring, using a simple hand tool. It forms a vibration-proof lock that won't shake free. Assembly time is reduced because of the one-piece construction . . . no loose parts to handle, nothing to tighten. Parts cost and assembly cost are reduced as much as 75%!

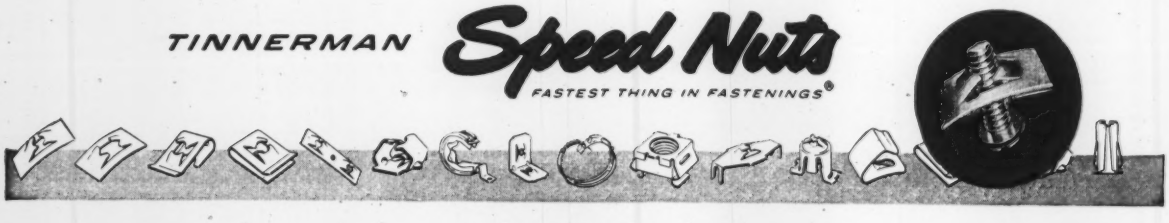
These SPEED CLIPS can be provided in sizes to fit any fractional-horsepower motor. They are designed to hold tight even under severest vibration and high starting-torque in any mounting position.

Ask your Tinnerman SPEED NUT sales engineer for more information and arrange for samples to test on your own assembly line.

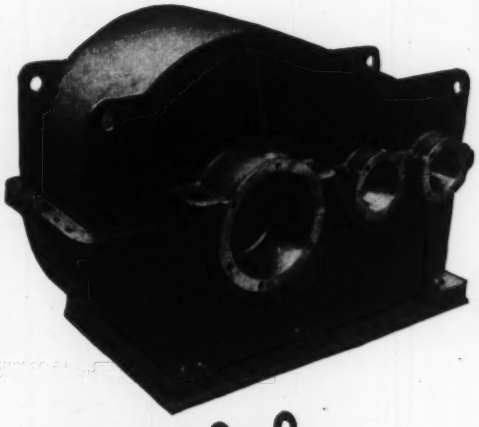


TINNERMAN PRODUCTS, INC. • Box 6688, Dept. 12, Cleveland 1, Ohio
Canada: Dominion Fasteners, Ltd., Hamilton, Ontario. *Great Britain:* Simmonds Aerocessories, Ltd., Treforest, Wales. *France:* Aerocessoires Simmonds, S. A., 7 rue Henri Barbusse, Levallois (Seine). *Germany:* Hans Sickinger GmbH "MECANO", Lemgo-i-Lippe.

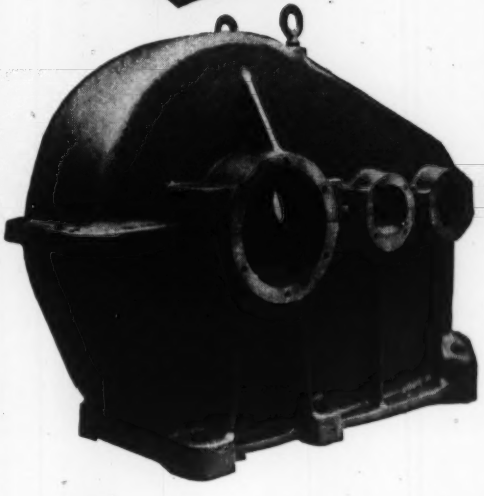
TINNERMAN **Speed Nuts**
FASTEST THING IN FASTENINGS®



—ITEM 201—



69 FABRICATED PARTS



2 GRAY IRON CASTINGS

***Plus* . . . 73% saving on cost of unmachined pieces.**

***Plus* . . . 20% saving on machining cost.**

The performance of the Gray Iron casting is superior to the assembly, because of Gray Iron's ability to absorb vibration. Furthermore, this characteristic provides the added dividend of quieter operation. Savings on the first three units made up the difference between pattern costs and template costs.

Look at the two housings. Consider appearance plus savings. Can there be any question about which is the better buy!

Somewhere in your plant, there must be a place where use of Gray Iron will save you money and improve your product.

For specific technical and business information, write direct to Gray Iron Founders' Society, Inc., National City—East 6th Building, Cleveland 14, Ohio.

This symbol assures you the most for your casting dollar

Here's why it pays to call in one of the more than 500 leading foundries displaying the Society symbol:

- The most recent technical and business information is available to each member through the Society to help you design better products at lower cost.
- The use of sound cost accounting procedures is recommended and encouraged among Society member foundries, assuring full value for your casting dollar.
- Improved castings result from the advanced techniques and the high sense of responsibility of Society members.

MAKE IT BETTER WITH GRAY IRON

GRAY IRON FOUNDERS' SOCIETY

—ITEM 202—

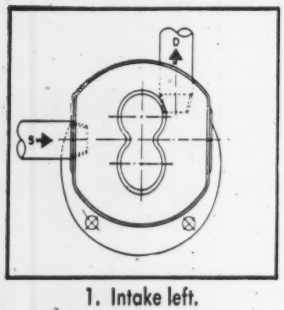
New MONOBLOC lets you hook up

WORTHINGTON MONOBLOC PUMP

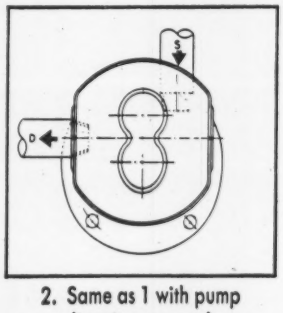
type GAFT, features rotary pump and close-coupled motor. It's just like the famous Worthington Monobloc centrifugal pump line except that coupling allows easy pump removal.

How you can use dual intake and discharge openings

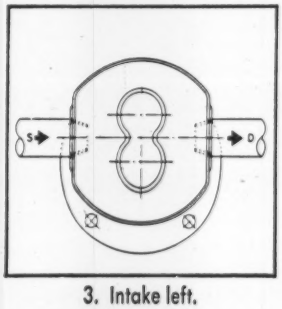
HERE ARE EIGHT OF THE 28 POSSIBLE ARRANGEMENTS:



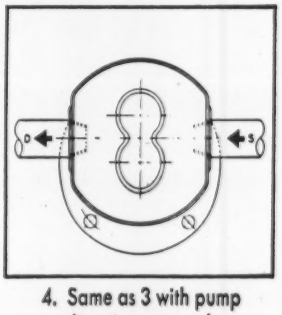
1. Intake left. Discharge top right.



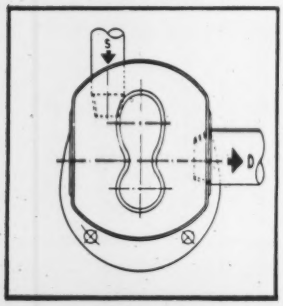
2. Same as 1 with pump direction reversed.



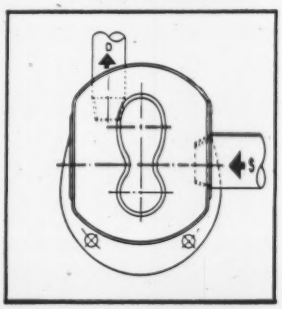
3. Intake left. Discharge right.



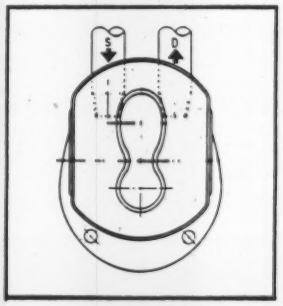
4. Same as 3 with pump direction reversed.



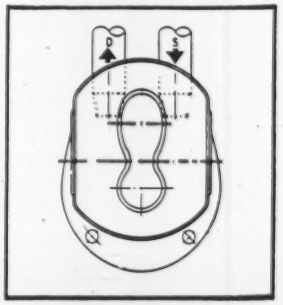
5. Intake top left. Discharge right.



6. Same as 5 with pump direction reversed.



7. Intake top left. Discharge top right.



8. Same as 7 with pump direction reversed.

rotary pump piping 28 ways!

This new Worthington Monobloc rotary pump is easy to design into compact new equipment or to adapt to existing layouts.

Dual suction and discharge openings, reversible pump direction, and four pump flange positions on motor add up to 28 possible arrangements to simplify pipe layout.

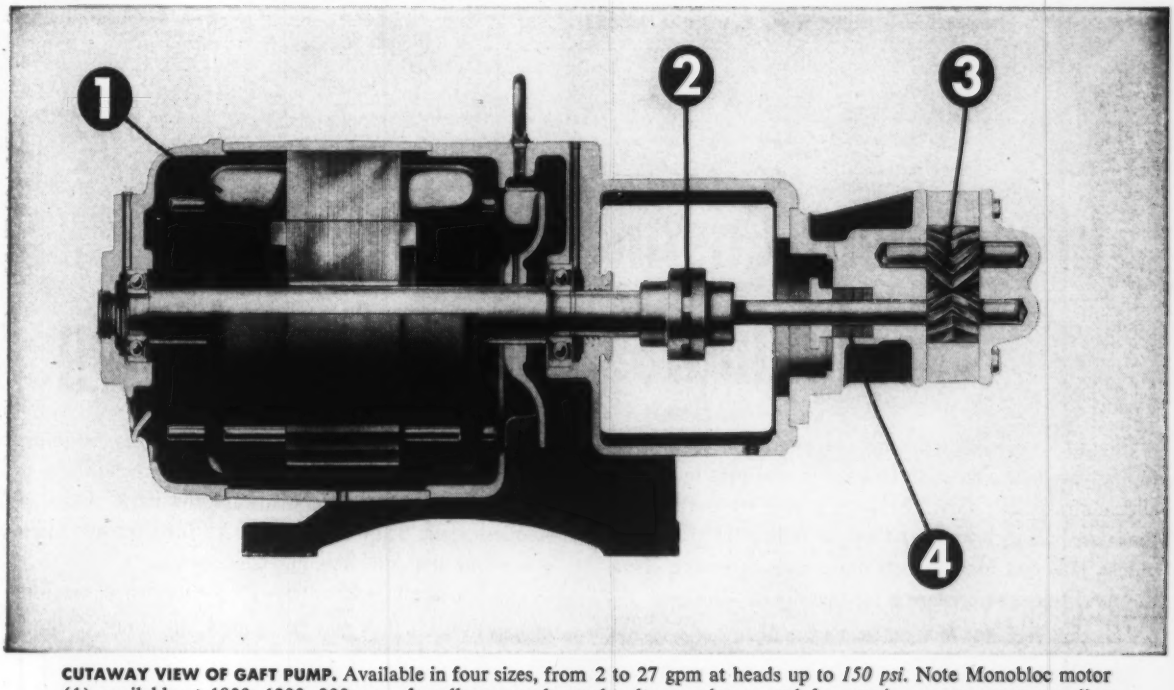
The Monobloc motor, on the new rotary, effects the same savings it has marked up for years on Worthington Monobloc centrifugal pumps. Fewer parts mean a more compact overall assembly that's easier to manufacture so it costs you less than separate pump, motor, coupling, and baseplate.

Standardization of pump and motor flange diameters and shaft lengths permit any pump to be mounted on any Monobloc motor.

There are no alignment problems with the Monobloc. Pump and motor are automatically aligned — eliminating end-thrust, binding, pipe strains, and resulting pump wear.

It's easy to service, too. A shaft coupling on the Monobloc rotary allows pump removal without disturbing the motor.

Get the whole story on the new Monobloc rotary pumps, type GAFT. Write today for bulletin W-484-S1. It gives complete data on features and applications. Worthington Corporation, Section PC.5.21, Harrison, New Jersey. PC.5.21



CUTAWAY VIEW OF GAFT PUMP. Available in four sizes, from 2 to 27 gpm at heads up to *150 psi.* Note Monobloc motor (1) available at 1800, 1200, 900 rpm, for all commonly used voltages, phases, and frequencies; motor-pump coupling (2) that allows quick pump removal; all-iron herringbone gear pump (3); packed stuffing box (4); a mechanical seal and/or relief valve are optional standard features.

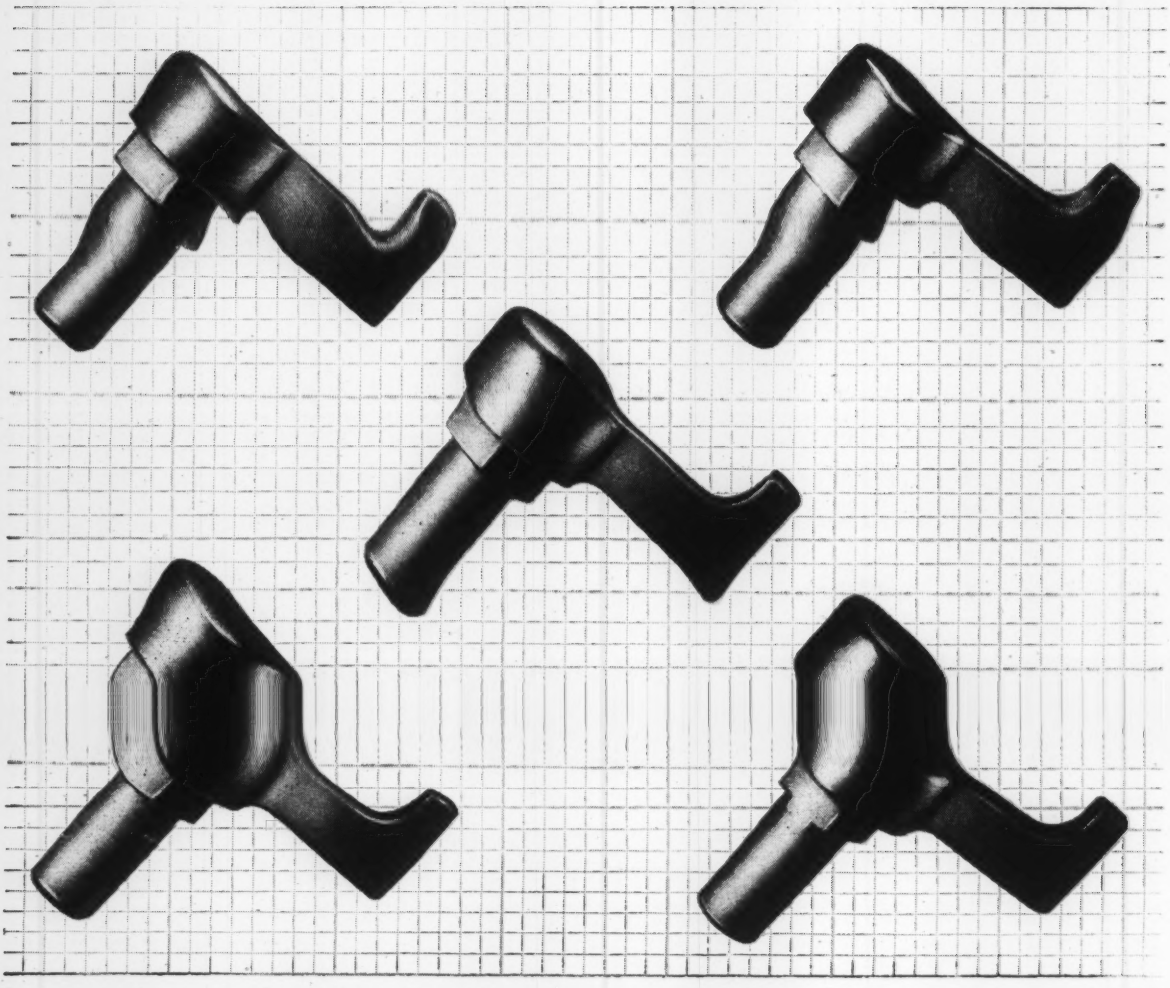
WORTHINGTON

SPECIFY THESE WORTHINGTON STANDARD PRODUCTS ON YOUR EQUIPMENT

Compressors • Pumps • Multi-V-Drives • Allspeed Drives

—ITEM 203—

For More Information Circle Item Number on Yellow Card—page 19



Cam Segment—weighs less than an ounce, measures less than ½ inch.

Investment-Casting improves part ... eliminates hours of machining

HAYNES' investment-casting process made it possible to mass-produce a small intricately-shaped part in a hard, abrasion-resistant alloy. The part, a cam segment, is less than one-half inch long, and weighs only a fraction of an ounce. It is cast to size. Only one simple threading operation is required to prepare it for operation.

The cam segment is used in a control instrument and rides against a valve shaft under pressures up to 35 lb. per sq. inch. At one time it was cast from a relatively soft metal and machined to final dimensions. The machining time for each cam was several hours—an expensive operation. The performance of the part was unsatisfactory because the metal used was selected for ease of machining—and could not stand up under the abrasive conditions.

The investment-cast segments are now made of type 410 stainless steel. They have been used for over one million operations and still show no signs of wear.

The freedom to select alloys for performance, regardless of how difficult they may be to machine, is one of the big advantages of HAYNES' investment-casting method. Intricate shapes in hard metals can be cast close to size, eliminating many machining operations. For full details on the process, write to our general sales office in Kokomo, Indiana, or any of the district sales offices listed below.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

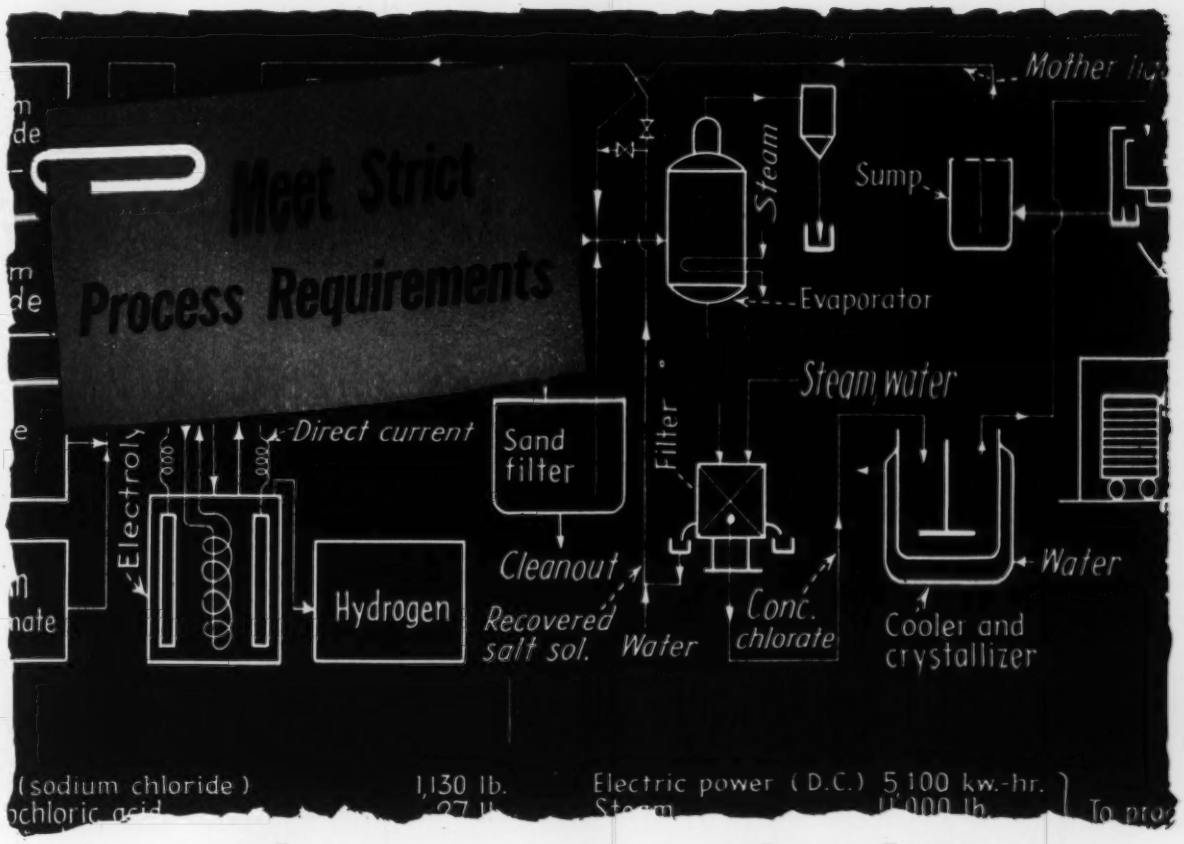
General Offices and Works, Kokomo, Indiana

Sales Offices

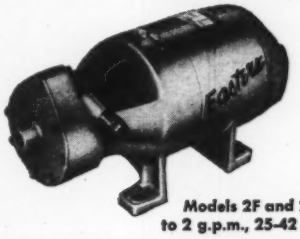
Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

"Haynes" is a registered trade-mark of Union Carbide and Carbon Corporation.

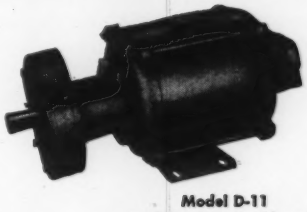
—ITEM 204—



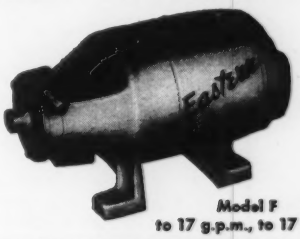
. . . with Eastern Centrifugal Pumps



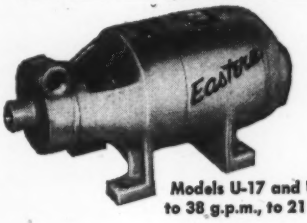
Models 2F and 2J
to 2 g.p.m., 25-42 p.s.i.



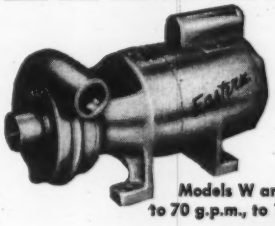
Model D-11
to 7.5 g.p.m., to 18 p.s.i.



Model F
to 17 g.p.m., to 17 p.s.i.



Models U-17 and U-34
to 38 g.p.m., to 21 p.s.i.



Models W and Z
to 70 g.p.m., to 11 p.s.i.

Models 3F and 3J
to 5 g.p.m., 29-65 p.s.i.

Recent redesign of these close-coupled Centrifugal Pumps has gained tremendous ruggedness and allowed for a wide selection of power requirements. In every detail of size, weight, space requirements, power, and costs, Eastern pumps fill the bill for strict process standards.

Six standard models range from 1/8th to 3/4 H.P., with capacities up to 70 G.P.M., pressures to 65 P.S.I. Eastern Centrifugal Pumps are available in Cast Iron, Bronze, Stainless Steel, Monel, and Hastelloy "C".

Eastern's engineering service offers many special models to meet your specific needs as to capacity and construction. Recommendations entail no obligation, and your inquiries are invited.

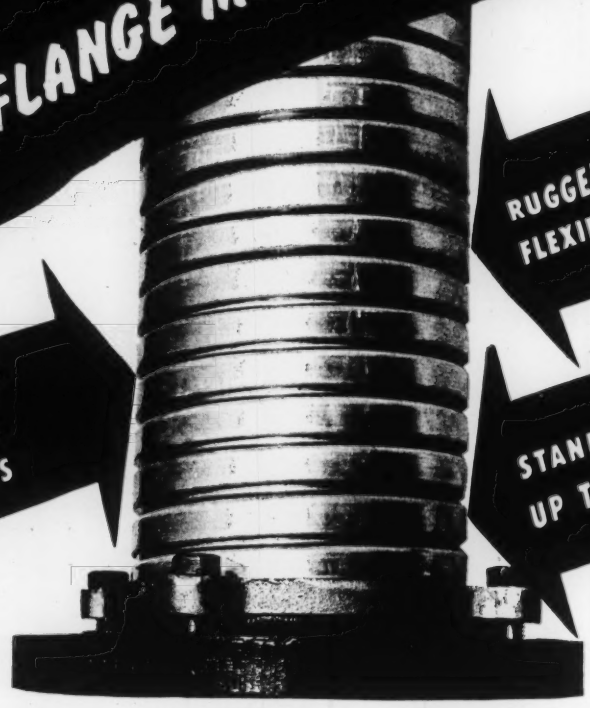
NEW EASTERN CATALOG

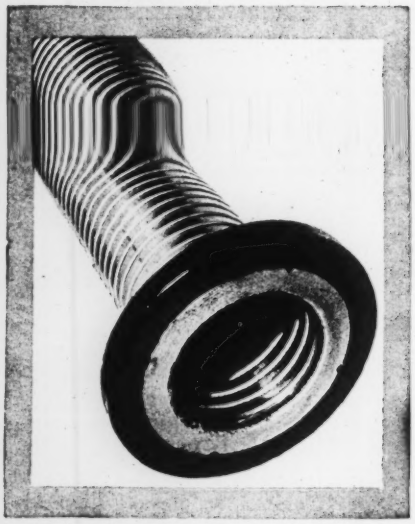
Eastern Centrifugal Pump Catalog contains engineering data, performance charts, diagrams and helpful general information. Request Bulletin 110J.

Eastern INDUSTRIES, INC.
100 SKIFF ST.
HAMDEN 14, CONN.

—ITEM 205—

NOW...FLEXIBLE HOSE AND FLANGE MADE FOR VOLATILES





Now, Penflex offers you the hose and flange to handle highly volatile liquids. It won't leak . . . is rugged . . . tough . . . flexible for the the most severe service.

This new hose has been designed, developed, tested and performance-proved in the chemical, petroleum and other industries conveying volatile liquids. It will withstand pressures up to 250 pounds and has proved its value in conveying oil, gasoline, kerosene and other volatiles. Available in sizes 2½" to 20" I. D.

The new Penflex Titepak Flange has patents pending and completes this leakproof assembly. It is leakproof under severe conditions . . . lighter in weight than other types of flanges . . . easier to connect. Penflex Titepak Flange assures greater efficiency in handling volatiles . . . lasts longer . . . and is tamperproof.

Penflex manufactures a complete line of four wall interlocked and seamless welded corrugated flexible tubing and automatic barrel fillers for the petroleum and chemical industries . . . accessories and fittings . . . and pneumatic rivet passers.

PENNSYLVANIA FLEXIBLE METALLIC TUBING CO.

7239 Powers Lane — Philadelphia 42, Pa.

Branch Sales Offices—BOSTON • NEW YORK • CLEVELAND • CHICAGO • HOUSTON • LOS ANGELES

COMBINES FLEXIBILITY WITH DURABILITY

—ITEM 206—

For More Information Circle Item Number on Yellow Card—page 19

What every designer should know about

FACE GEARS for Angular Drives

DESIGN OF "ON CENTER" FACE GEARS
Published by:
THE FELLOWS GEAR SHAPER COMPANY
Springfield, Vermont, U.S.A.
DESIGN OF "OFF-CENTER" FACE GEARS

FACE GEARS have distinct advantages which the designer should know. They can be spur or helical, "on-center" or "off-center." The mating members are pinions. Both are generated on Fellows Gear Shapers by cutters having involute teeth.

Utilization of face gears results in a simple, compact design that can be economically manufactured and assembled.

Consider all these advantages:

- quality cutting at low cost
- easier and lower cost assembly
- no appreciable thrust
- pairing for reversal of direction
- tooth bearing not affected by axial displacement of pinion

GET ALL THE FACTS:

Information on the design and cutting of Face Gears is free for the asking. Just write to:

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont

Branch Offices: 319 Fisher Building, Detroit 2
5835 West North Avenue, Chicago 39
2206 Empire State Building, New York 1
6214 West Manchester Avenue, Los Angeles 45

THE PRECISION LINE **Fellows** *Gear Production Equipment*

Four-Part Series now available

in single-reprint form—

PRECISION GEARING

New methods of design analysis have evolved to meet the performance requirements of gearing for control applications. Objectives of these methods are the regulation or elimination of backlash and control of inaccuracy such as errors in angular position and velocity ratio. How to appraise and control backlash and inaccuracy sources, and how to encompass these aspects in design are the objectives of this series of articles.

by G. W. Michalec

PART 1—Backlash Sources and Their Evaluation

PART 2—Antibacklash Devices and Backlash Calculation

PART 3—Inaccuracy Sources and Their Evaluation

PART 4—Control and Calculation of Inaccuracy

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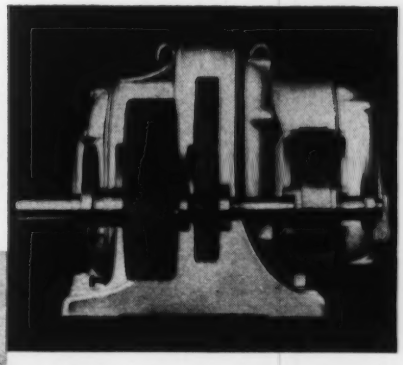
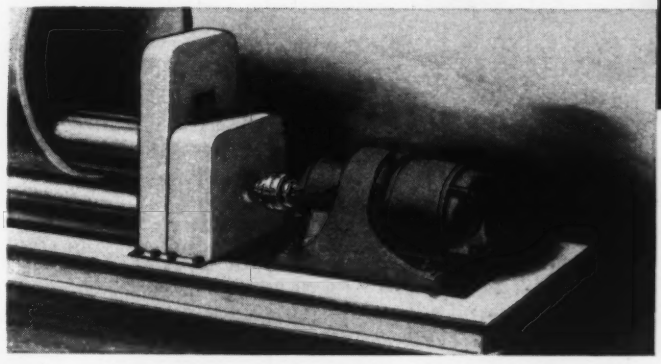
☐ Please bill me

Simplify WITH SYNCROGEAR

INTERNALLY GEARED POWER

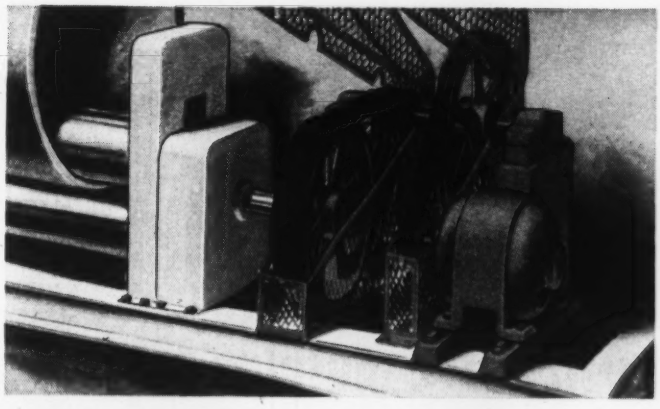


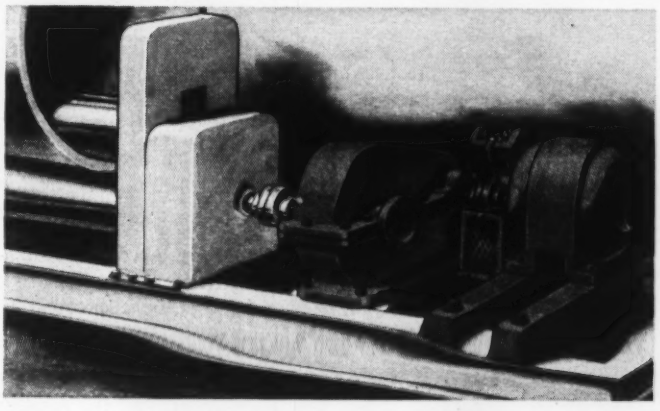


U.S. SYNCROGEAR MOTOR

5 TO 10,000 RPM
⅓ TO 30 H.P.

Reject CUMBERSOME HOOKUPS





The U. S. Syncrogear is more than a motor. Its "packaged" assembly includes a high speed motor, an enclosed sealed gear-train, correctly engineered for the load, always in exact alignment, all mounted in a single case which saves space and eliminates the ungainly appearance of complicated hookups.

You don't have to calculate chain, sprocket, bearing or shaft requirements, or invest in separate mechanisms, special fabricated guards, extra pulleys and belting when you direct-connect a Syncrogear.

More and more manufacturers are using Syncrogears on their products to improve appearance and increase saleability.

Free – Mail coupon for all new descriptive multicolor booklet with all the facts you should know about geared motors.

U.S. *Electrical* MOTORS

U. S. ELECTRICAL MOTORS Inc. MD-2
P. O. Box 2058, Los Angeles 54, Calif., or Milford, Conn.
Send Syncrogear Booklet

NAME_____

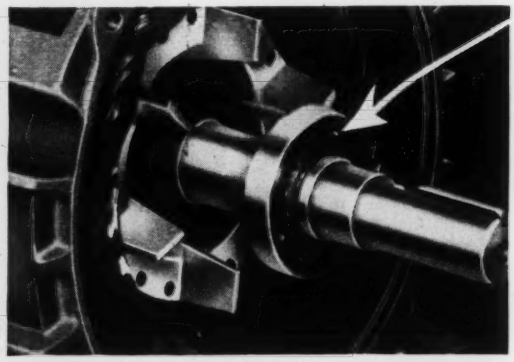
COMPANY_____

ADDRESS_____

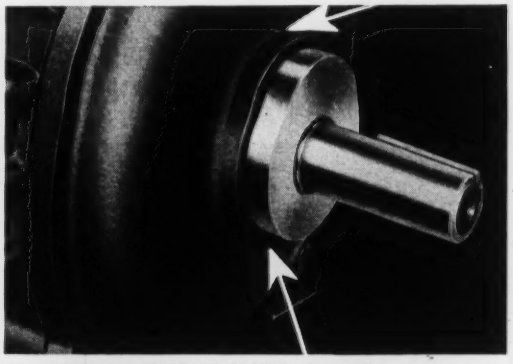
CITY_____ ZONE____ STATE_____

—ITEM 208—

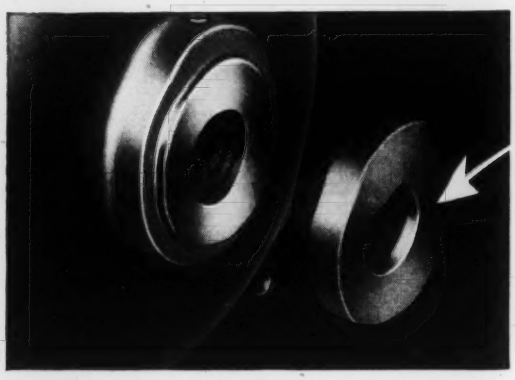
Wagner ELECTRIC MOTORS... the choice of leaders in industry



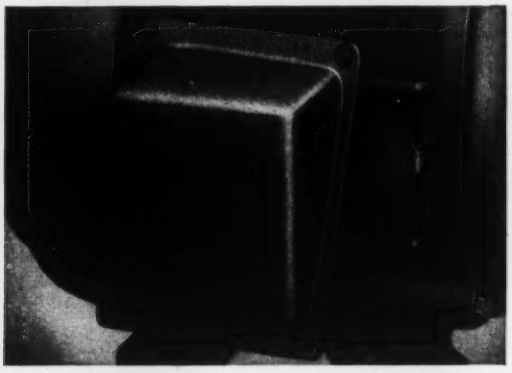
HEAVY-DUTY BALL BEARINGS—Highest quality bearings of more than ample capacity to carry heavy loads provide long trouble-free service.



BEARINGS CAN BE RE-LUBRICATED—These Wagner motors can be re-lubricated when necessary to prolong bearing life. New grease can be added—old grease removed through openings provided in top and bottom of bearing housing.

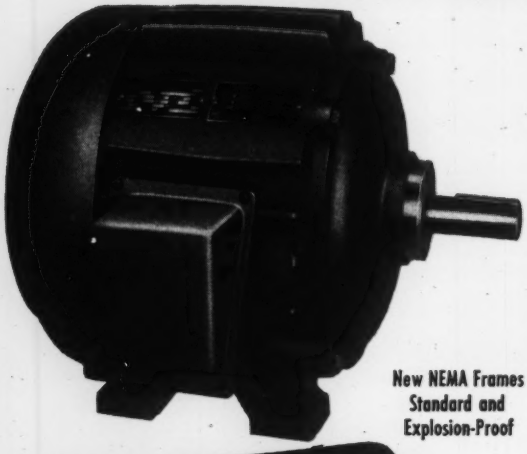


BEARINGS STAY CLEAN—Both ends of these motors are equipped with running shaft seals to keep dirt, dust and water from the bearings. There's no grease loss because bearing housings have effective seals to prevent escape of grease.



EASY TO CONNECT—Large diagonally-split conduit box which can be mounted in any of four convenient positions, provides ample room for making connections. Leads are readily identified by numbers stamped on the terminal bushing.

Wagner totally-enclosed motors mean less down-time for machine tools



New NEMA Frames Standard and Explosion-Proof

Wagner totally-enclosed fan-cooled motors are particularly suitable for use on all types of machine tools.

They are fully protected against damage from steel filings, chips, dust, dirt, fumes and moisture. They require no maintenance other than periodic lubrication.

If appearance is a factor, you'll find that the pleasing proportions of these motors give them that functional beauty obtained only when the design is fundamentally *right*.

Ribs on the corrosion-resistant cast iron frames add mechanical strength and increase the surface area for more efficient cooling. Full information and principal dimensions are given in Bulletin MU-203 which is yours for the asking.

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—ITEM 209—

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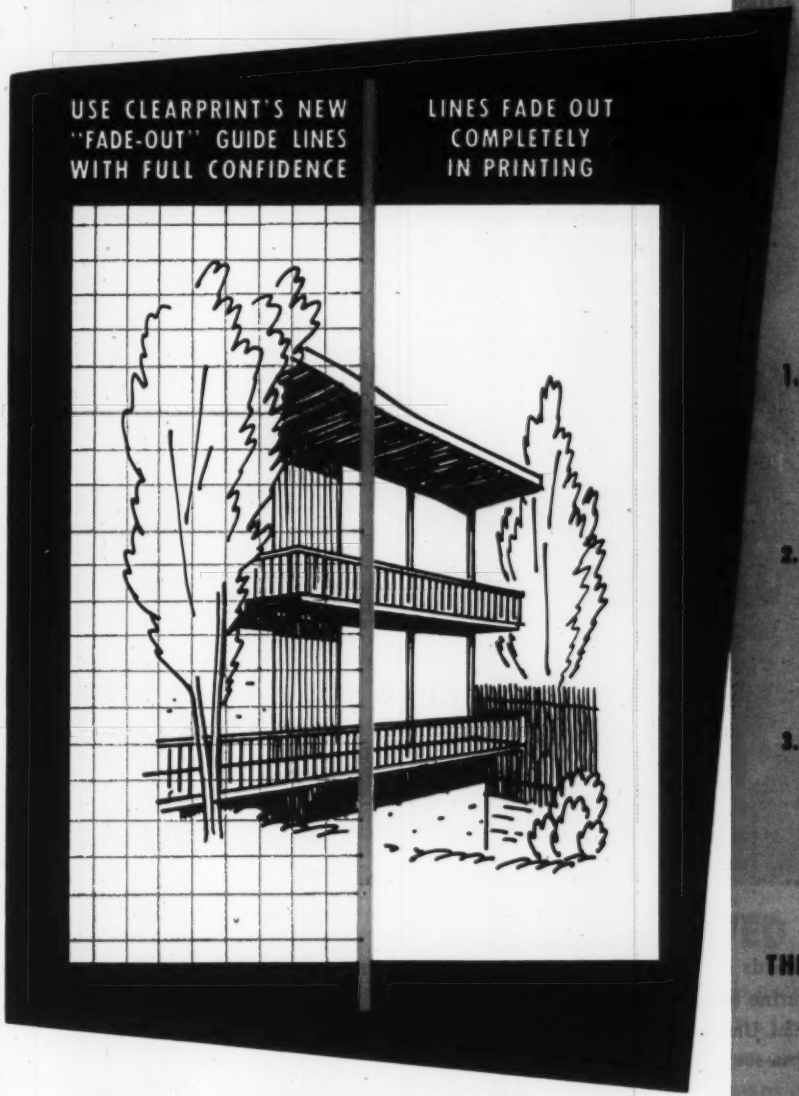

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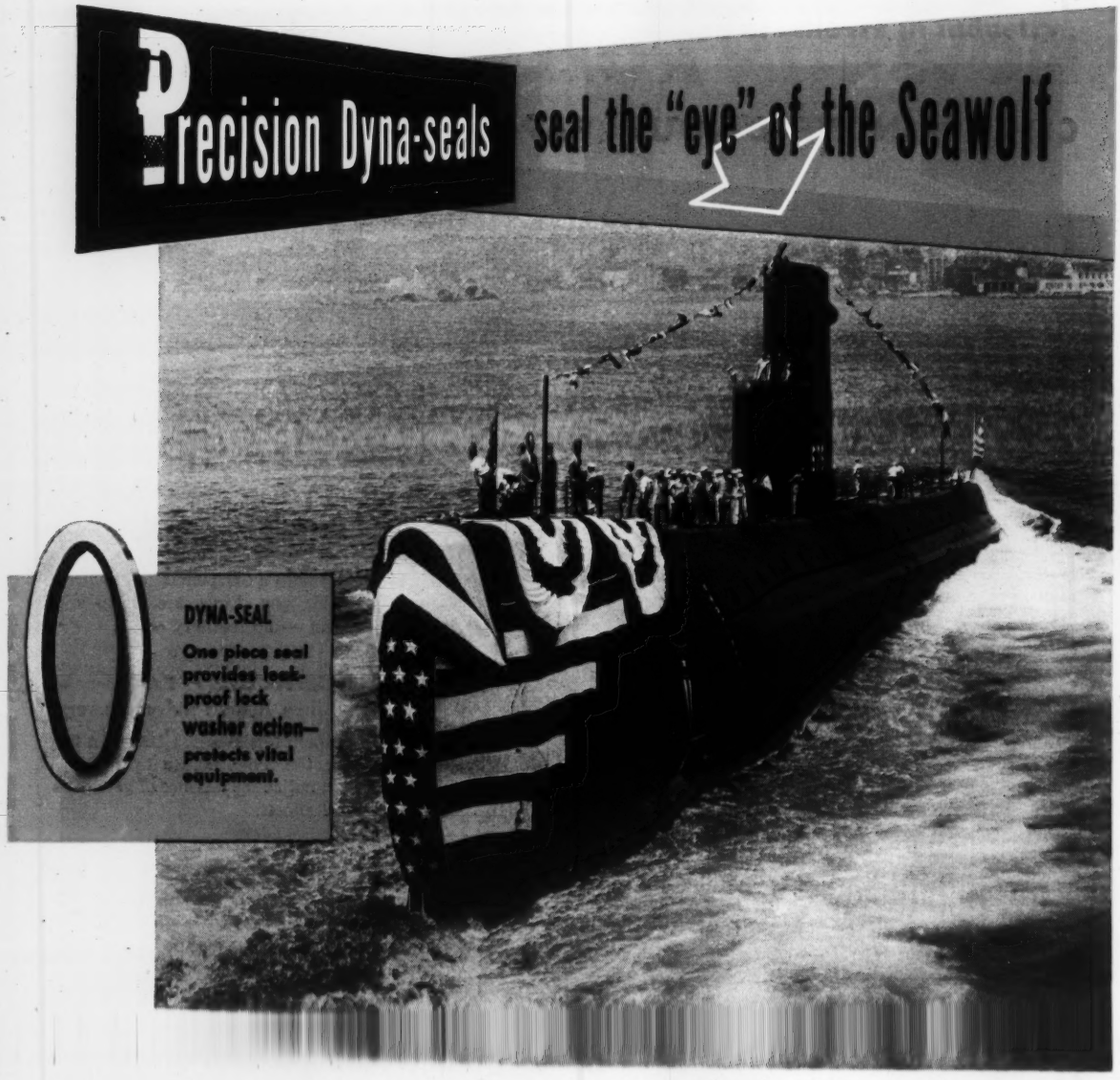

The use of Dyna-seals under bolt heads of the periscope mounting on the nuclear submarine Seawolf will provide positive sealing up to 10,000 P.S.I. Uncompromising requirements of the Precision Dyna-seal were controlled by rigid specifications.

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—ITEM 212—

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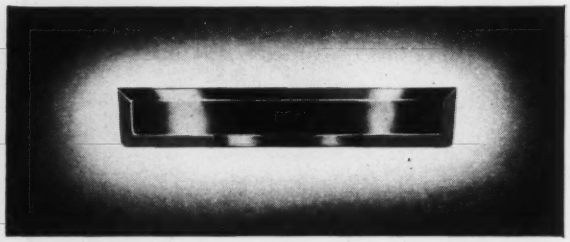
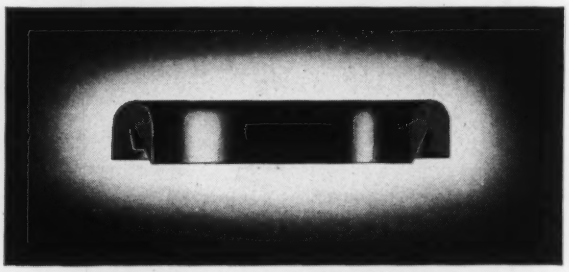
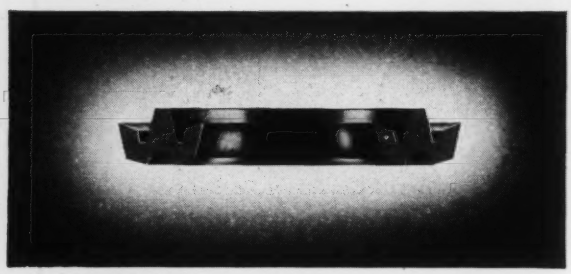


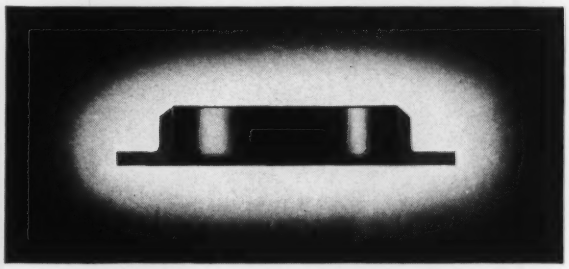
1. Type "A" Packing Cups for pistons *(the original "square heel" cup design)*



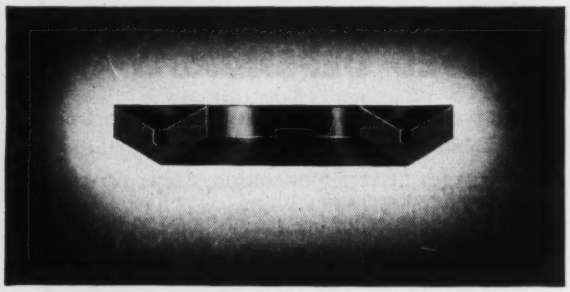
2. Sea Ring packing for rods



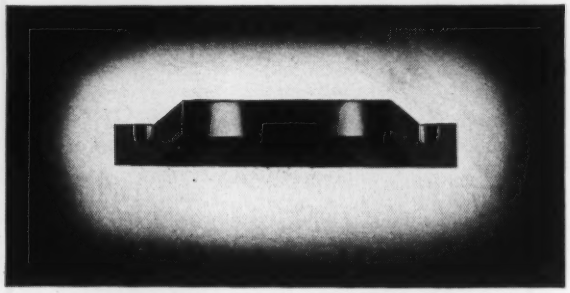
3. Uneepac Packing for rods and pistons



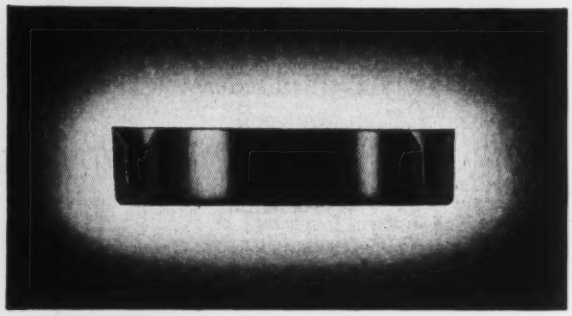
4. Hat Cup Packing for rods



5. V-Rings packing for rods and pistons



6. Cumpac #239 packing for rods



7. U-Cup Packing for rods and pistons

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JOHNS-MANVILLE JM PRODUCTS

Johns-Manville MOULDED PACKINGS

—ITEM 213—
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JENKINS Fig. 106-A

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Renewable Composition Disc
BRONZE GLOBE VALVE
150 lbs. Steam 300 lbs. O.W.G.
⅛ in. to 3 in.

Making a Work Horse a Champion

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Fig. 106-A not only looks better — it proves out better in performance. In any comparison, its long-life, low-upkeep record has always set the standard. That is the true measure of valve cost — and it is the reason why industry's shrewdest buyers will settle for nothing less than Fig. 106-A quality.

The Fig. 106-A "family", with interchangeable parts, provides Globe, Angle, and Check patterns to meet 90% of average valve needs.

Ask your Jenkins Distributor for full information, or write: Jenkins Bros., 100 Park Ave., New York 17.

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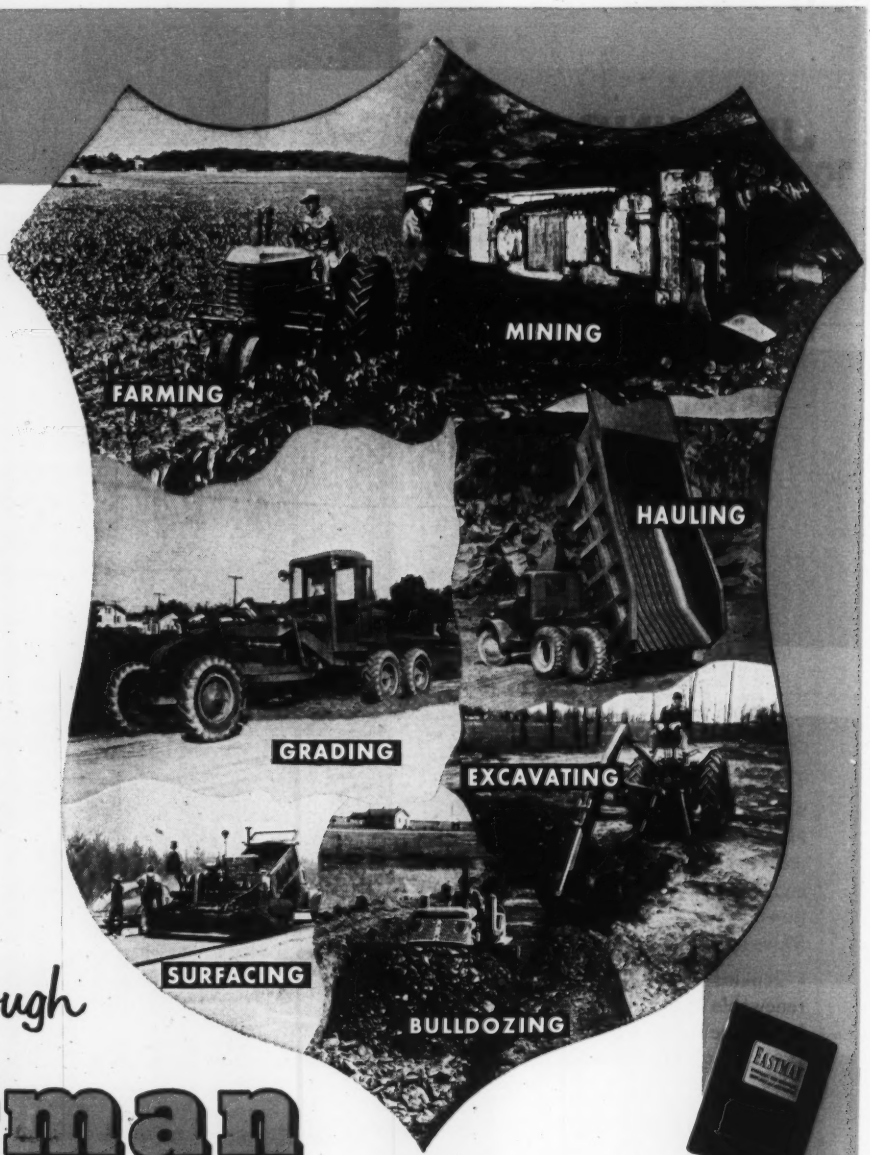

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—ITEM 215—
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MACHINE DESIGN
FEBRUARY 9, 1956

The Freedom to Choose

REPEATED warnings are apt to dull the awareness of danger. Thus, recent widely publicized information concerning Soviet education of scientists and engineers may by now be falling on deaf ears.

It has been reliably estimated that between 1950 and 1960 Soviet Russia will have graduated 1,200,000 scientists and engineers as against 900,000 in the United States. By 1960 they may well have more than we.

The importance of these statistics in terms of the development and maintenance of industrial and military power is obvious to any engineer. Yet the figures alone do not tell the whole story.

There is every evidence that the Soviets fully realize the importance of proper utilization and adequate recognition of engineers. The Soviet engineer is well supported by technicians and other aides who relieve him of nonengineering duties. He is also trained as a specialist and required to concentrate his efforts in his specialty. While such a rigid system admittedly may fail to develop well-rounded engineers with the flexibility to adapt themselves to change, it can lead to highly effective on-the-job performance.

The Russian engineer is also a member of the privileged class. He has plenty of incentive to succeed as an engineer and technical man. A ruthless system, too, rather quickly eliminates the incompetents.

Since there are no salesmen in Russia we can also be sure that no Soviet engineers are being lost to their profession through that avenue, as so many are in this country. In any event, over there they simply don't have the freedom to choose their form of employment.

If the United States is to maintain a competitive position in technical manpower, many obvious things must be done by industry, by educators and even by government. Engineers, too, can help.

Their God-given talents plus the skill and competence which they have acquired, often through the sacrifices of others, are precious national assets. The engineer's freedom to trade these assets, a privilege denied his Communist counterpart, is not to be taken lightly.

When frustration with his seemingly slow progress tempts a man to give up engineering, he might well ponder the obligation which his freedom of choice imposes. Failure to exercise the choice wisely could contribute to the loss of the freedom.

Colin Carmichael

EDITOR

Picking Profitable

By Philip R. Marvin
Economist
American Viscose Corp.
Philadelphia, Pa.

AN ENGINEERING executive who spent his boyhood in a race-track town remarked that picking product winners is a lot like picking turf winners. Both require horsesense. True, of course, winners may be picked by lucky choice, but the odds favor the seasoned veteran who can draw upon knowledge and experience.

Sound product lines make sound business. Stability and growth depend upon sound product lines. "For Rent or Sale" signs are soon nailed to factory buildings when engineers fail in their job of picking profitable products.

Knowledge and understanding of factors brought to bear in picking product winners can be acquired by any engineer. This essential knowledge isn't the private property of a select few; it's available to anyone. Its acquisition demands time and attention—but too much of both, for some.

Over the years the successes and failures of others in business ventures have made available a large amount of data which can be capitalized upon to avoid pitfalls in picking profitable products. Spurning the counsel of experience is inconsistent with the philosophy of engineering, a science founded upon principles and laws having roots in practical experience.

Engineers must think in broad economic terms. It is just as important to select products having economically justified end-use as it is to design products in an economical manner. Engineers must apply the same orderly analytical process in studying end-use requirements that they apply in the design of products to satisfy these needs. Recognition and application of this orderly process of evaluating proposed products develops the latent horsesense so valuable to those engineers who have successful records for picking profitable products.

Do Better Mousetraps Sell?

The development of sound product concepts starts with what might seem to be a backward step. One must progress through an unlearning phase. Fallacious ingrained concepts must be cleared away. Otherwise they clutter up the straight thinking process essential to picking profitable products.

We have been told that if we build a better mousetrap than our competitor, even though we put our factory in the center of the woods, customers will beat a path to our door. This is nonsense. Such thinking by engineers has probably caused more business headaches and heartaches than any other single factor. Sales are made when customers want a better mousetrap and are willing to pay for it.

Engineers are inclined to look at product design from the viewpoint of customer's needs. Customers think in terms of wants, not needs. John Doe may not need a new fountain pen, but if he wants one, a potential sale is created for the fountain pen manufacturer who has a new pen to offer.

Sales are made by satisfying wants, not needs. Some years ago one leading automobile manufacturer learned at disastrous expense that the need for an automobile incorporating airflow styling did not coincide with the then current wants of customers.

Products

A successful product can be selected by guesswork. However, a much higher degree of success is assured if a detailed analysis and a systematized approach are followed. This article outlines a well-marked route to the profitable product goal.

In picking new products, pick those products which give customers what they want. Forget what the customers need. Don't limit your thinking to technical requirements. This is much too narrow a base for successfully picking profitable products.

Willingness To Pay

The price a customer is willing to pay is the significant price in evaluating new products. Pricing related to costs does not take into consideration what the customer is willing to pay. A clear understanding of this latter figure is vital in picking profitable products.

You may not need a $15 fountain pen—a dollar pen may be adequate—but your willingness to pay the higher price creates a market. Low-priced electric motors may cost more in the long run than higher priced motors, but unless you are willing to pay the higher price, no real market exists for the higher priced product.

Some argue that when customers don't want what they really need and aren't willing to pay a price they can't afford not to pay, these customers should be educated. It takes both time and money to do this job. Customer education isn't feasible in the short run period, the period with which one must be concerned.

The Mousetrap Fallacy

This discussion of the so-called mousetrap fallacy results from a confusion of the real significance of wants, needs, and willingness to pay. It is commonly encountered in engineering thinking. A thorough knowledge of its implications is important. Until this fallacy is recognized and understood, one can't pick profitable products. The mousetrap fallacy points up the importance of three questions pertinent to sound product programs. What do customers want? What are they willing to pay? Can it be provided at an attractive profit? The search for answers to these questions is not an easy task. A systematic approach makes the job easier.

Basic Product Questions

Any systematic analysis undertaken for the purpose of picking profitable products must probe specific areas of the product picture. There are nine fundamental questions for engineers to ask—and answer!

Answers to these questions are the data necessary to arrive at sound product decisions. Risk of errors in judgment will be magnified by the neglect of any one area. Brief examination will reveal the particular significance of each.

General Industry Background

1. ANNUAL INDUSTRY SALES
   - How large is the industry?
   - What volume of business does this type of product represent within the industry?
   - What volume of business could be derived from this specific product?
2. CURRENT INDUSTRY TRENDS
   - What has taken place in the following areas?
     - Research
     - Engineering
     - Manufacturing
     - Sales
     - Finance
     - Distribution
3. OUTLOOK

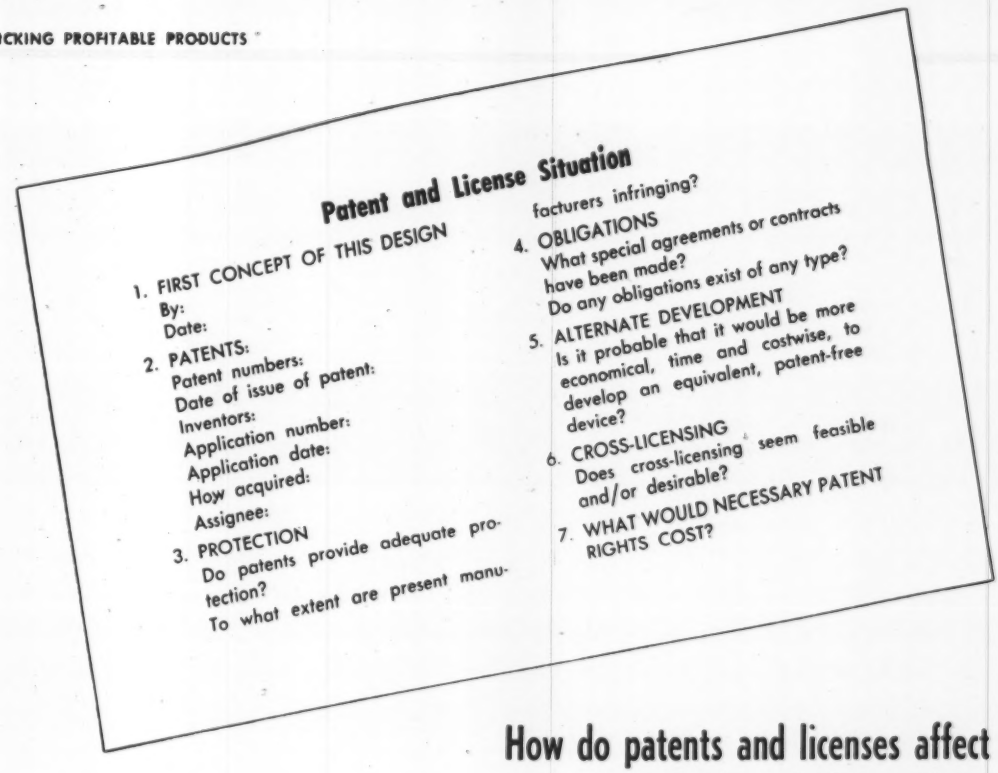
What is the outlook for the industry identified with the proposed product?

A clue to the probable success of any product can be found in the outlook for the industry the product will enter if put on sale. For example, if you plan to introduce an automatic control that will be installed primarily on milling machines, get a picture of the outlook for the entire machine-tool industry, along with the milling machine segment. Before giving any final serious consideration to a new product, a comprehensive knowledge of its industry should be developed.

You may want to place the product on the market even when the industry doesn't show healthy signs of growth or even when definite signs of industry decline are established, but sound judgment dictates adapting product lines to healthy industries. In making an analysis of the industry, a checklist of pertinent factors is a valuable aid.

Product Characteristics

1. CONSUMER BENEFITS
   - What does the product provide?
     - New function?
     - Improved function?
     - Lower costs?
   - How does it relate to:
     - Economy?
     - Labor savings?
     - Health?
     - Time savings?
     - Appearance?
     - Comfort?
     - Safety?
2. PRACTICABILITY
   - Is this the best way we know to accomplish these objectives?
   - If not, what is the best way?
   - Why not adopt that?
3. COSTS
   - Is this the lowest cost method of accomplishing these objectives?
   - If not, what is the low cost approach?
   - Why not adopt that?
4. INSTALLATION
   - Is there any installation problem?
   - If so, what is it?
   - If so, how much of a sales deterrent is it?
5. PRODUCT SALES DETERRENTS
   - What principal weaknesses are presented by the proposed product?
   - How important are these as sales deterrents?
6. MODIFICATIONS INDICATED
   - For better performance:
     - Design
     - Capacity
     - Simplicity
   - To meet "approval" requirements:
     - How important?
     - How costly?
   - For increased sales appeal:
     - Styling
     - Weight
     - Size
     - Adaptability
     - Operating cost
     - Safety
   - For lower cost:
     - Capacity
     - Design
     - Simplicity
7. TECHNICAL TESTS
   - Should further technical tests be made before test sales campaigns?
     - What tests?
     - Why?
     - Cost?
     - How long will they take?



Patent and License Situation

1. FIRST CONCEPT OF THIS DESIGN
   By:
   Date:
2. PATENTS:
   Patent numbers:
   Date of issue of patent:
   Inventors:
   Application number:
   Application date:
   How acquired:
   Assignee:
3. PROTECTION
   Do patents provide adequate protection?
   To what extent are present manufacturers infringing?
4. OBLIGATIONS
   What special agreements or contracts have been made?
   Do any obligations exist of any type?
5. ALTERNATE DEVELOPMENT
   Is it probable that it would be more economical, time and costwise, to develop an equivalent, patent-free device?
6. CROSS-LICENSING
   Does cross-licensing seem feasible and/or desirable?
7. WHAT WOULD NECESSARY PATENT RIGHTS COST?

How do patents and licenses affect introduction of the product?

Patent and licensing relationships should be thoroughly reviewed. Has the door been closed by existing patents to any consideration of the particular product other than by agreement with the patent owner?

If no patents exist covering the proposed product, the engineer is free to explore the merits of a patent application. As a general rule, it is advisable to secure a maximum amount of patent protection.

A new product can be launched with optimum security of investment only when it is possible to answer in the affirmative, the question: Do we have adequate patent protection to cover our development costs and to insure an attractive return on our investment.

What are the important features of the proposed product?

To pick a profitable product one must "know" each product in the group from which the selection is to be made. Knowing implies an understanding of more than surface characteristics. Engineers, by virtue of their training have the best opportunity of developing a thorough knowledge of products.

The proposed product must be seen in true perspective with respect to its ability to perform. Forget loyalty to pet projects. Examine product proposals critically, without bias.

What effect will the proposed product have on relationships growing out of other products offered to the trade?

Products influence the make up of all corporate relationships. Once a line of products becomes well established, its ac-

tive part in these relationships becomes so familiar it is not recognized. The introduction of any new product carries with it the necessity of a series of adjustments.

A number of important relationships that should be taken into consideration by engineers are presented in the accompanying outline. Not the least of these, in importance, relates to restrictive understandings with other manufacturers. Often these restrictive understandings are not recognized. Entry into a new line of activity by a manufacturer may be interpreted by a customer or competitor as a breach of an implied agreement. Engineers should be alerted to evaluate the effect of the product upon all of these corporate relationships.

Effect on Other Products and Relationships

1. OTHER MANUFACTURERS
   What is the nature of any restrictive understanding existing?
2. EXISTING PRODUCTS
   Does this product eliminate or reduce the market for any existing product?
3. OPERATING PRINCIPLES
   Does the required new method of operation conflict with other methods of the firm?
4. OTHER INTERESTS
   Would entry into the proposed line jeopardize the management's or stockholders' interests in any way?
5. COMMUNITY RELATIONSHIPS
   Would these be affected?
6. SUMMARY
   Is net incidental effect favorable?

Market

1. CUSTOMER CHARACTERISTICS
2. GEOGRAPHIC PECULIARITIES OF MARKET
   Does market vary greatly geographically?
   How?
3. LIST PRICE NECESSARY TO SECURE VOLUME
4. OPERATING COSTS AND INFLUENCE ON MARKET
5. TIE-IN INTEREST IN MARKET DEVELOPMENT
6. LIFE OF PRODUCT
7. LIFE OF MARKET
8. SATURATION
9. ESTIMATED SALES
10. WHEN IS THE OPTIMUM TIME TO STRIKE THE MARKET?
11. HOW SOON CAN THE ITEM BE PLACED ON THE MARKET?

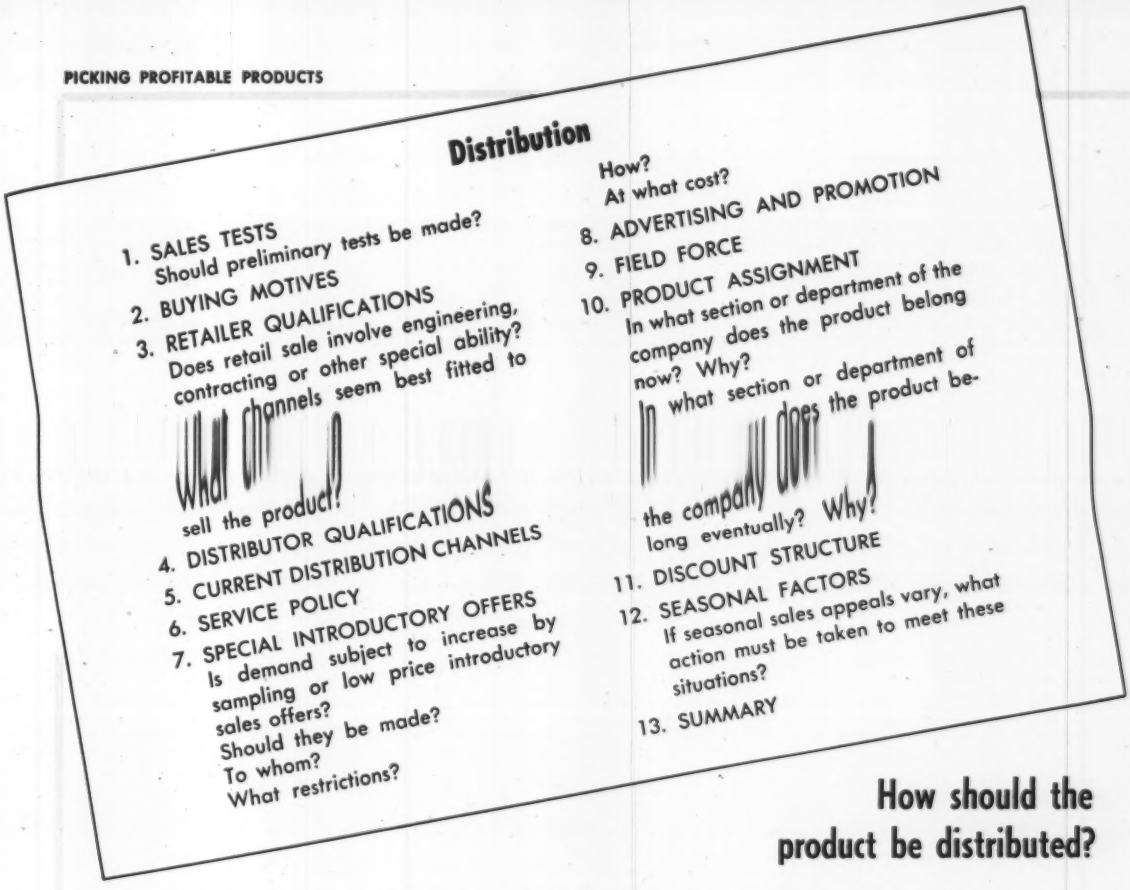
What is the market for the product?

Frequently engineers consider this the most important factor to be evaluated in picking profitable products. This view has no basis in fact. Each product evaluation factor is equally important in arriving at a sound choice. Each must be so regarded.

A market appraisal is one of the vital steps in product selection. The relative potential strength of the market for various products under consideration will modify the importance of other factors such as patents, product characteristics and the like.

For example, with adequate patent protection, a relatively limited market can prove attractive even where profit margins are slim because the risk is made negligible by the protective patent coverage. To illustrate again, where other product lines make available both a sales and service force, a marginal market for a new product may prove of interest. The cost of tapping this market would be nominal.

Market appraisals must be comprehensive. The true significance of the data will only be revealed to the engineer after he has completed a survey of all factors.


Distribution
1. SALES TESTS
Should preliminary tests be made?
2. BUYING MOTIVES
3. RETAILER QUALIFICATIONS
Does retail sale involve engineering, contracting or other special ability?
What channels seem best fitted to sell the product?
4. DISTRIBUTOR QUALIFICATIONS
5. CURRENT DISTRIBUTION CHANNELS
6. SERVICE POLICY
7. SPECIAL INTRODUCTORY OFFERS
Is demand subject to increase by sampling or low price introductory sales offers?
Should they be made?
To whom?
What restrictions?
How?
At what cost?
8. ADVERTISING AND PROMOTION
9. FIELD FORCE
10. PRODUCT ASSIGNMENT
In what section or department of the company does the product belong now? Why?
In what section or department of the company does the product belong long eventually? Why?
11. DISCOUNT STRUCTURE
12. SEASONAL FACTORS
If seasonal sales appeals vary, what action must be taken to meet these situations?
13. SUMMARY

How should the product be distributed?

Neither the soundness of a product nor the existence of the market for the product establishes that it will be economically feasible to reach the people (1) who want the product, (2) with the product, (3) at the point of sale.

In picking profitable products, distribution factors must be surveyed to establish the probable degree of success of the proposed product.

For example an engineer evaluating a new industrial motor must know that a large proportion of industrial motor sales are made directly to equipment manufacturers. Successful introduction of a new motor requires a staff that can reach these equipment manufacturers. Other products have slightly differing but equally important requirements which must be considered.

Engineers can't afford to neglect a study of the characteristics of the particular distribution system required by each product under review. A product can't be sold unless a customer is contacted. This is the job the distribution program performs in the success or failure of a new product offering

What competition can be anticipated?

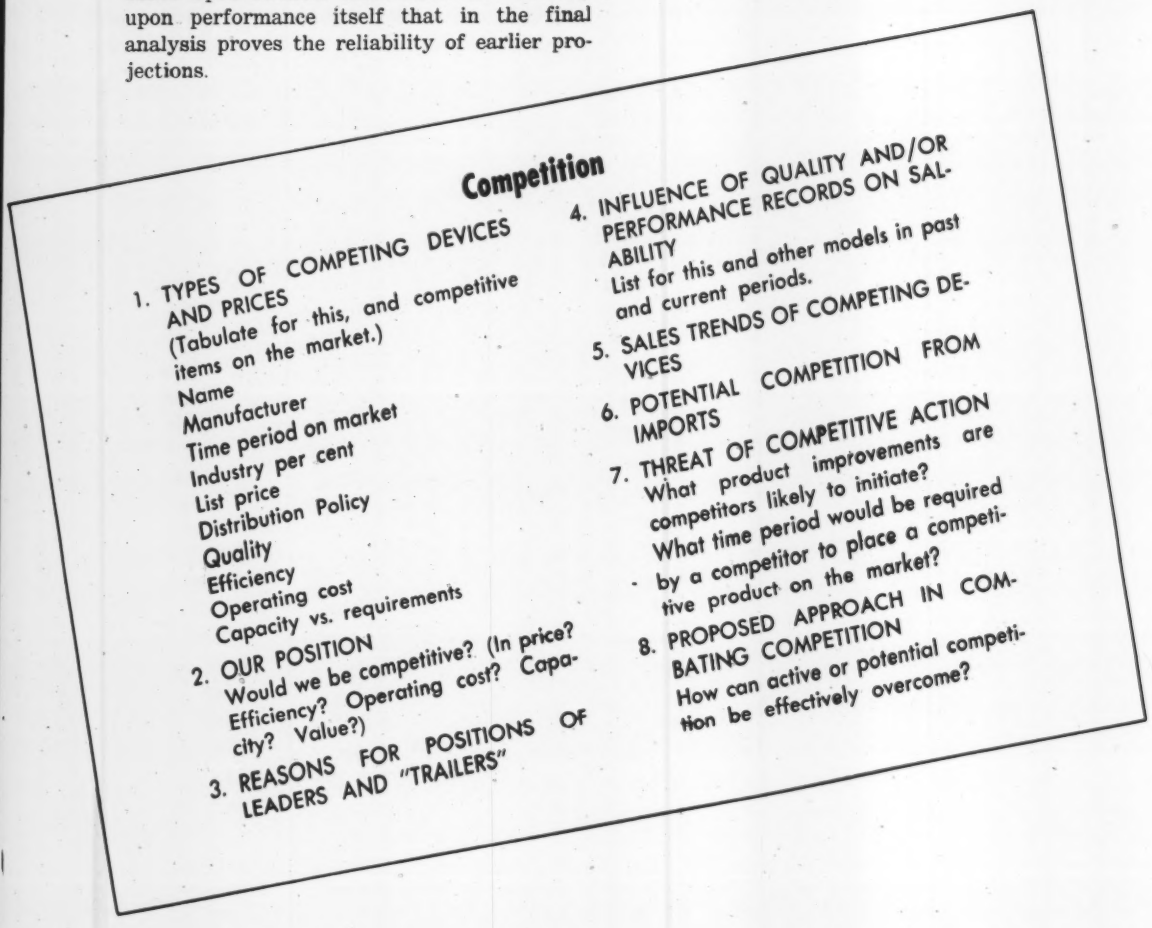
Engineers often encounter difficulty when they cost new products prematurely. Cost factors can't be correctly computed until the product evaluation survey has reached this point in its systematic development.

Everything that has preceded this step has been deliberately designed to develop a background for cost studies. The importance of costs exerts a pressure upon the engineer for premature figures. When he succumbs to these pressures he should remember that errors in calculations are remembered long after the contributing pressures have been forgotten.

It is the engineer's duty and responsibility to call attention to the importance of adequate basic data as a foundation for cost estimates in order that the cost estimates can function as reliable guides. Failing in this duty and responsibility, the engineer must ac-

cept contributory responsibility for any consequences.

Success in picking profitable products results first from performance projections based upon reliable basic data and secondly upon performance itself that in the final analysis proves the reliability of earlier projections.


Competition
1. TYPES OF COMPETING DEVICES AND PRICES
(Tabulate for this, and competitive items on the market.)
Name
Manufacturer
Time period on market
Industry per cent
List price
Distribution Policy
Quality
Efficiency
Operating cost
Capacity vs. requirements
2. OUR POSITION
Would we be competitive? (In price? Efficiency? Operating cost? Capacity? Value?)
3. REASONS FOR POSITIONS OF LEADERS AND "TRAILERS"
4. INFLUENCE OF QUALITY AND/OR PERFORMANCE RECORDS ON SALABILITY
List for this and other models in past and current periods.
5. SALES TRENDS OF COMPETING DEVICES
6. POTENTIAL COMPETITION FROM IMPORTS
7. THREAT OF COMPETITIVE ACTION
What product improvements are competitors likely to initiate?
What time period would be required by a competitor to place a competitive product on the market?
8. PROPOSED APPROACH IN COMBATING COMPETITION
How can active or potential competition be effectively overcome?

What are the estimated costs and potential profits?

To evaluate product proposals, the engineer must know both the product and competition. First, the attention of the engineer must be focused in the direction of the individual product proposal. Next, he must look beyond at competition. Any product's success or failure is determined in part by its competition. Engineers must examine this competition. Who are the competitors? How important are they? What are their practices?

Not the least important is the question: What time period would be required to get on the market with a competitive product? The answer to this question reveals the competitive risk associated with the product offering.

For example, consider the relative risk inherent in the threat of market entry in the case of a new steel producer contrasted with a new machine shop. One would take years, the other days. In the former the competitive picture is free from the risk of precipitous shifts; in the latter, the picture can change over night.

Both competition's strength and

stability must be assessed. Changes in the status quo can seriously affect profit ratios.

Cost and Profit Potentials

1. COST TO GET INTO BUSINESS ON A REGULAR BASIS
   - Research
   - Development
   - Engineering
   - Patent
   - Manufacturing
   - Distribution
   - Advertising
   - Management and other service costs
2. UNIT COSTS
   - Initial
   - Ultimate
3. NET SELLING PRICE
   - Initial
   - Ultimate
4. PROFIT AND LOSS ESTIMATE
   - First year of operation
   - Sales
   - Gross margin
   - Expenses
   - Net profit
   - When will sales volume liquidate costs-to-date plus interest on investments?
5. MARKET PRICE STABILITY
   - Does price show long-range stability?
   - If not, how will it influence profits?
6. INVESTMENT REQUIREMENTS
   - How many years will be required to achieve a relatively stable profit position?
   - How much will the cost, out-of-pocket, over this period represent in a total dollar figure?
   - Does venture seem to offer good profit potentials?

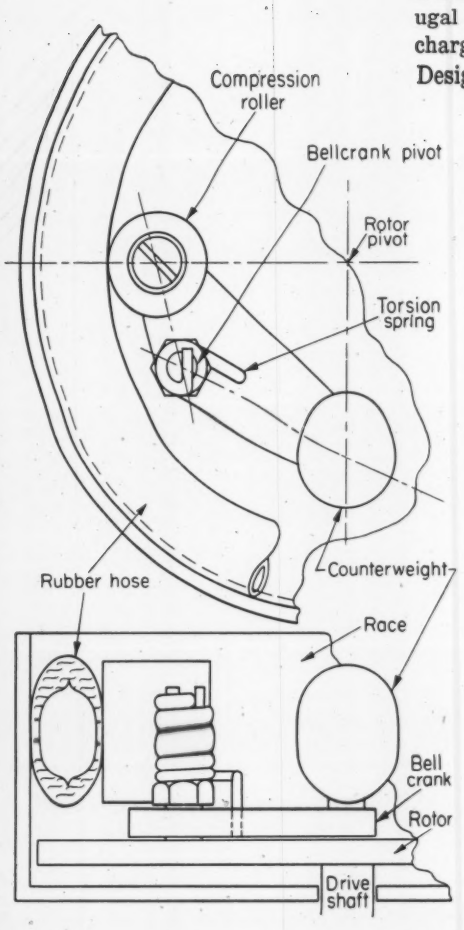
How much of a threat does technological development present?

Research plays a dual role. Research offers a source of new products and at the same time it presents a constant threat that these new products will be obsoleted by further research before engineers can complete their work and get new products on the market. The engineer in evaluating a new product proposal must not only look at the potential for the product but he must also appraise the threat of early obsolescence from subsequent developments of the research laboratory. Rapidly advancing technology can shorten a product's life span to the point where it will be impossible to recover the investment necessary in introducing a new product on the market.

The research threat is a two-pronged thrust. Advanced designs may make the product unsalable. New developments in other technologies may cause a market shift. Consider, for example, the impact of television on the motion picture industry.

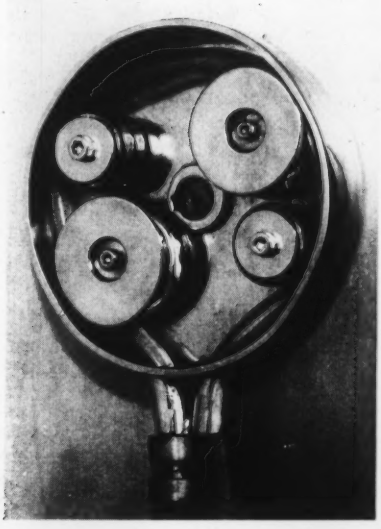
Engineers should exercise their imagination in probing research and development activities for clues to new developments that can have a significant impact upon product proposals under review.

scanning the field for Ideas



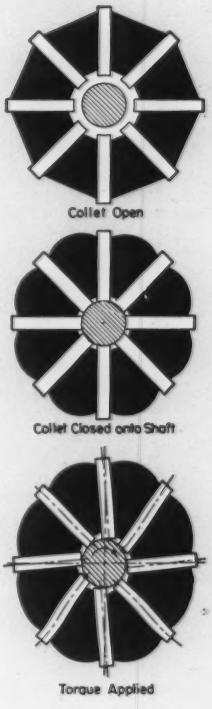
RUBBER-HOSE PUMP design employs centrifugal flow control to provide a constant fluid-discharge rate regardless of pump drive-shaft speed. Design parameters also can be modified to give variable flow rates. Developed by the Jerome Murray Corp., the pump consists essentially of two roller-bellcrank assemblies, which are mounted on a shaft-driven rotor, and a loop of rubber hose placed around the inner face of a circular frame. On each roller-bellcrank assembly is attached a centrifugal counterweight.

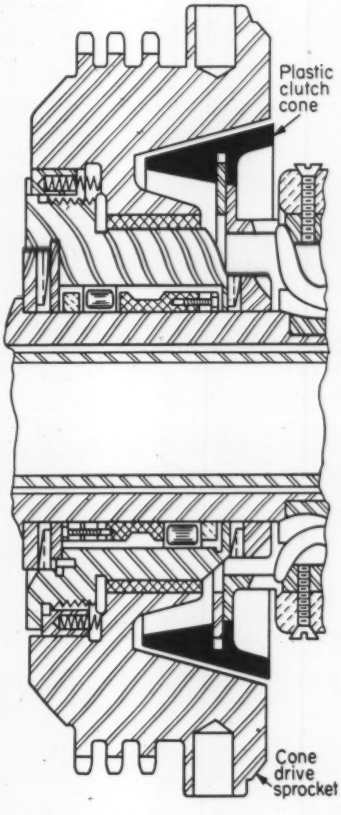
In one model of this design the rollers completely collapse the hose at standstill and at low speeds, since the bellcrank is spring-loaded. Rotation of the rotor with the rollers in contact with the inside of the hose loop creates a pressure difference between hose inlet and and outlet. As drive-shaft speed increases, the counterweights fly out pulling the rollers away from the hose, reducing the volume of liquid pumped per revolution. Whether flow rate is constant or variable depends on spring torsion, bellcrank design, and the size and relative position of rollers and counterweights.



UNIFORM LOCKING PRESSURES for secure assembly of shaft and hub type members are provided by a variable-bore collet construction. Developed by the Jacobs Mfg. Co. for use in drill, tap and lathe chucks, the Rubber-Flex collet is composed of a number of alloy-steel jaws molded in Hycar synthetic rubber. This rubber framework, which allows a certain amount of free movement of each jaw, makes it possible to keep the jaws parallel and in full contact with the shaft.

In application the jaws are forced radially inward by means of a tapered sleeve to provide a gripping action. Grip is further increased by a self-tightening toggle effect produced by a slight twisting of the jaws in the rubber as the collet is closed down onto the shaft.

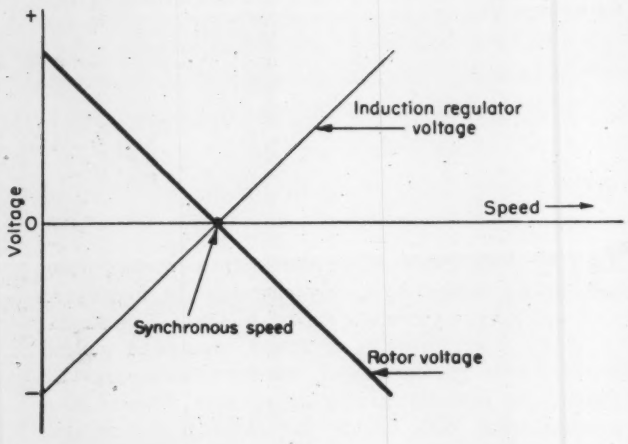


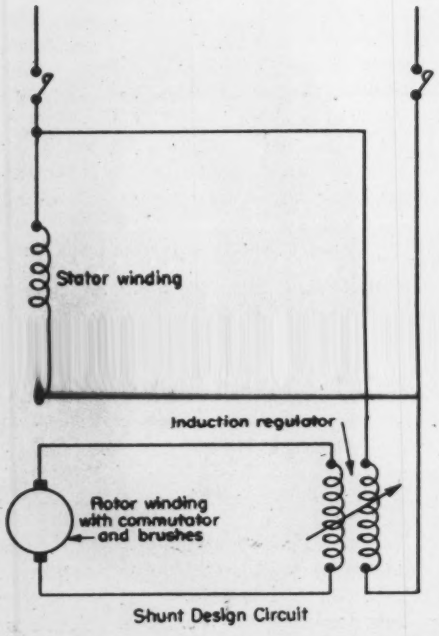


PLASTIC FRICTION SURFACES in a movable-cone clutch design reduce drive reversing time in high-speed Brown and Sharpe automatic screw machines. The single-piece clutch cone, made of Synthane macerated molded phenolic plastic produced by a special process, provides a lightweight, low-inertia rotating element. Bonded to a supporting steel disk during the molding process, the plastic material is long-wearing, grips smoothly and resists warping or deterioration under heating.

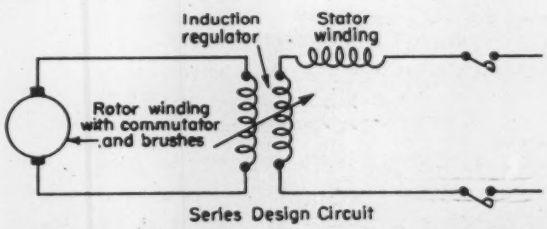
ADJUSTABLE-SPEED CONTROL of an ac motor design is accomplished by a unique method of varying rotor voltage. A wide range of speeds above and below synchronous speed are provided by an induction regulator which is connected in the motor circuits. Developed by Laurence, Scott and Electromotors Ltd., England, and manufactured under license in this country by the Bogue Electric Mfg. Co., the motor can be designed with either a series or a shunt speed-torque characteristic.

The stator design of this drive is like that of a conventional induction machine, while the rotor is similar to the armature of a dc motor with brushes and a commutator plus an auxiliary winding. In operation, when the induction regulator is adjusted so that its voltage opposes the rotor voltage of one polarity, speed of the motor decreases until the rotor voltage balances the regulator voltage. By further adjustment of the induction regulator to produce a reversed polarity, the rotor voltage is built up in the opposite polarity and the motor runs above synchronous speed. Here, also, speed stabilizes when balance between rotor voltage and the reversed regulator voltage occurs. By this speed control method, power is taken from the rotor and returned to the supply at speeds below synchronous vice versa above synchronous.





Shunt Design Circuit



Series Design Circuit

Practical tips on

Keeping a Technical File

By James J. Lahm

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PROPERLY organized and maintained, a personal technical file can be a valuable working tool for the engineer. Even if a technical file is provided as part of the company library, the engineer will usually find it advantageous to keep his own file which can be tailored to fit his particular needs.

File arrangement will depend on the individual and will vary according to work habits and job interests. To be practical however, any system used should meet three basic requirements: (1) it should be simple, (2) it should be inexpensive and (3) it should provide for easy location of specific information. This article discusses the various factors to be considered in setting-up a personal technical file and outlines a method of data organization that has proved satisfactory.

Why keep a file?

As the pace of technical advance continues to increase, the engineer must rely more and more heavily on current literature to keep abreast of developments. Handbooks have long been recognized as a primary storehouse of engineering information, and they offer a partial solution to the problem. However, their usefulness has practical limits, leaving a gap that must be filled by technical magazines, journals and periodicals, and manufacturer's literature. These publications are the most practical source of up-to-date information on new products and engineering techniques and methods.

The need for and advantages of periodical literature are readily apparent. They are a well-established line of enginering communication. In some cases, the announcement of a new component or material has marked the turning point between success and failure of a design project. In other cases, it has been a description of a circuit, a mechanism or a technique that stimulated thinking and thereby opened the door to a practical problem solution.

Periodical technical literature available to the engineer today includes a large number of different types of publications. The problem, however, is not so much one of where to get information but rather of how to store it until it is needed. The most logical solution, particularly when reading time and space available for storage are limited, is the personal technical file.

What to keep in a file

In general, a technical file will contain two classes of information: (1) material not otherwise readily available and (2) material that is more usable in its file form than as provided by other sources. Such material will include magazine articles, technical papers, manufacturer's literature and personal notes.

Magazine articles and technical papers will probably predominate. Some publications offer clip-sheets or reprints to their readers, free of charge or at a small nominal cost. When neither arrangement applies, it will be necessary either to have the material reproduced, or to obtain a personal copy of the publication from which the desired sheets can be removed.

Manufacturers make available a vast quantity of engineering data and general information on their products. Some of this material will usually qualify for inclusion in a technical file. Catalogs are generally bulky and, therefore, it is sometimes

more satisfactory to include only those portions that are especially pertinent. For example, saving a section which discusses theory of operation or a listing of standard dimensions might be advantageous.

Little needs to be said about saving personal notes. If they are not too highly specialized and are likely to be of use at some later date, they should be kept.

In general, it is wise to be discriminating; material that summarizes a particular subject, or articles that describe recent or unusual developments, will propably be the most useful. The young engineer is sometimes overenthusiastic, and be-

Typical File Organization

Materials
(General)
Coatings
Nonmetals
(General)
Ceramics
Dielectrics
Glass
Laminates
Lubricants
Plastics
Rubber
Metals
(General)
Ferrous
Nonferrous

Fastening
(General)
Adhesives
Fusion
Rivets
Seals
Special methods
Screws

Circuit Components and Design
(General)
Circuits
Batteries
Capacitors
Connectors
Diodes
Fuses-breakers
Permanent magnets
Potentiometers
Printed circuits
Rectifiers
Relays-solenoids
Resistors
Switches
Timers-delays
Transformers
Transistors
Tubes

Electronics
(General)
Communications
Industrial
Laboratory

Electrical
(General)
Contacts
Magnetic amplifiers
Motor controls
Rotating machinery

Mechanical
(General)
Bearings
Chains-belts
Clutches-brakes
Couplings
Engines
Gears
Mechanisms
Seals
Springs
Tools
Vibration-shock

Fluid Power
(General)
Filters
Hydraulic
Pneumatic
Pumps
Vacuum
Valves

Instrumentation
(General)
Acoustic
Chemical analysis
Dimensional measurement
Electrical
Fluid flow measurement
Optical
Photoelectric
Physical property measurement
Pneumatic
Radioactivity
Speed measurement
Thermometry
Weight measurement

Automation
Sociological
Processes
Special machines
Materials handling

Servomechanisms

Computers
(General)
Digital
Analog

General Design
Design techniques
Tolerances-fits
Computational aids
Analytical equipment
Cost estimates
Product design
Industrial design

Professional Development

Management
Legal
Organization
Personnel
Labor relations

Ultrasonics

gins by saving all of the engineering literature that is available to him. This approach obviously is not practical. A reasonable objective might be to include:

1. Specific articles and information pertaining to the current area of job activity.
2. General information on prospective and allied fields.

Since these areas of interest are subject to change, flexibility is an important requirement of the filing system arrangement selected.

How to organize a file

The only justification for a technical file is its practical utility. To be useful, its contents should be well organized so that they can be readily located. Similarly, the system should be simple so that its upkeep does not require excessive time. An arrangement which is too complicated may be neglected and may subsequently perish.

One system that meets these requirements uses three-ring loose-leaf binders equipped with suitable dividers. When several different binder capacities are used, they can, in most cases, be chosen so that an entire binder is devoted to a particular section of the file.

Since it is a simple matter to add or delete material, a loose-leaf file is easy to keep up to date. Also inherent to this type of system are the advantages of expandability and portability. All of these features combine to make a file that is easy to maintain and use.

Divider leaves with appropriate tabs are used in conjunction with the loose-leaf binders. Each main division is preceded by a divider with a large or colored tab, while dividers with smaller tabs are used to indicate the subdivisions. In most cases, only two degrees of division will be necessary. If it is found that a more detailed classification is needed, it is generally better to expand horizontally rather than vertically. Experience has shown this case to be one where simplicity is a measure of efficiency.

Divisions and subdivisions should be chosen to fill the requirements of the individual who will use the file the most. His areas of interest should be the guide in this selection. An example of a practical arrangement is shown in the accompanying *Typical File Organization*. In this case the primary user is a design engineer whose interests are principally mechanisms, circuits, and instrumentation. To illustrate how a technical file can be tailored to fit the needs of the user, it will perhaps be helpful to analyze the contents of this outline.

The first two subjects, *Materials* and *Fastening*, are rather basic and therefore will be found in most engineering files. For the sake of convenience the *Materials* section has three degrees of subdivision. This breakdown simplifies the filing of information that covers both metals and nonmetals.

The next nine divisions pertain specifically to the user's fields of activity. *Circuit Components and Design* was set up so that subdivisions in the *Electrical* and *Electronics* sections would not have to be duplicated. Some of the more closely related subjects, such as relays and solenoids, have been combined in one subdivision. Just as *Fluid Power* was once a subdivision of *Mechanical*, the material now comprising the *Instrumentation* section was originally a part of the *Circuit Components and Design* section under the subheading of transducers. *Automation, Computers* and *Servomechanisms*, although all closely related, are distinctive enough to require separate headings.

The remaining classifications of the file represent the user's allied interests. For example, the *Ultrasonics* section contains material which was compiled as a result of a special investigation. In time, if this interest is not sustained, this material will probably be deleted. A wide variety of subjects are included in the *General Design* section. Although most of its subdivisions are self-explanatory, it should be pointed out that the section on computational aids includes such things as nomographs and mathematical shortcuts, and that on analytical equipment refers to items like high-speed photographic equipment.

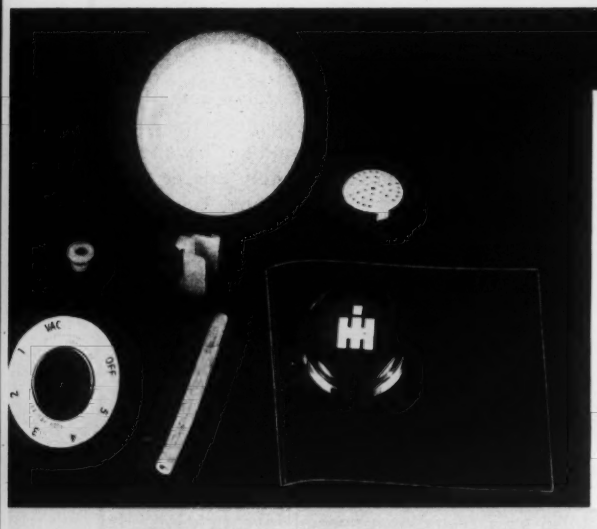
The *Professional Development* and *Management* headings reflect the aspirations of the engineer involved. Articles on speaking, writing, and creative thinking might be filed under a personal development subheading.

Because of the nonspecific nature of some articles, it is not possible to subclassify them accurately. These items are considered general and are filed between the main divider and the first subdivider of the appropriate section. Thus, it may be necessary to look at least two places for the desired information: the specific subdivision and also the general section of that same division. To avoid a special division, specifications and standards are considered as general and are filed accordingly in their appropriate section.

When the foregoing system is employed, the need for cross references is virtually eliminated. If cross references are used, however, they can be conveniently listed on the first page of each division and subdivision. These listings can also be readily extended to include references to information contained in brochures and manuals that are too bulky to be included in the file.

They Say . . .

"Every outstanding scientist or engineer is in his own way an artist. That is why he is able to reach out into the unknown and grasp a new truth which remains invisible to others."—REAR ADMIRAL H. G. RICKOVER, *chief, Naval Reactors Branch, Division of Reactor Development, U. S. Atomic Energy Commission.*



Fastening and Joining Plastic Parts

By Ralph E. Wallenbrock, *Advance Design Engineer, International Harvester Co., Evansville, Ind.*

MANY properties of plastics impose definite design limitations when the plastics are fastened or joined. Taking these special characteristics into consideration, this article discusses and illustrates methods of fastening and joining plastic parts to other plastics and materials.

The terms fastening and joining are often used interchangeably. However, in this article fastening will include the mechanical methods of holding two or more parts together. Joining will refer to plastic attachment methods such as cementing, welding, casting-in-place, solvent bonding, heat sealing, or two-stage molding.

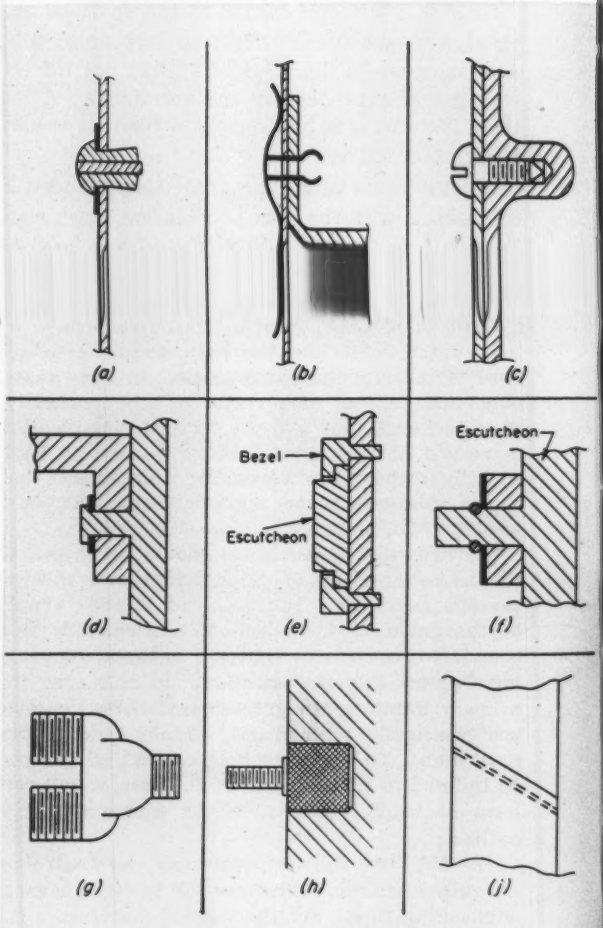


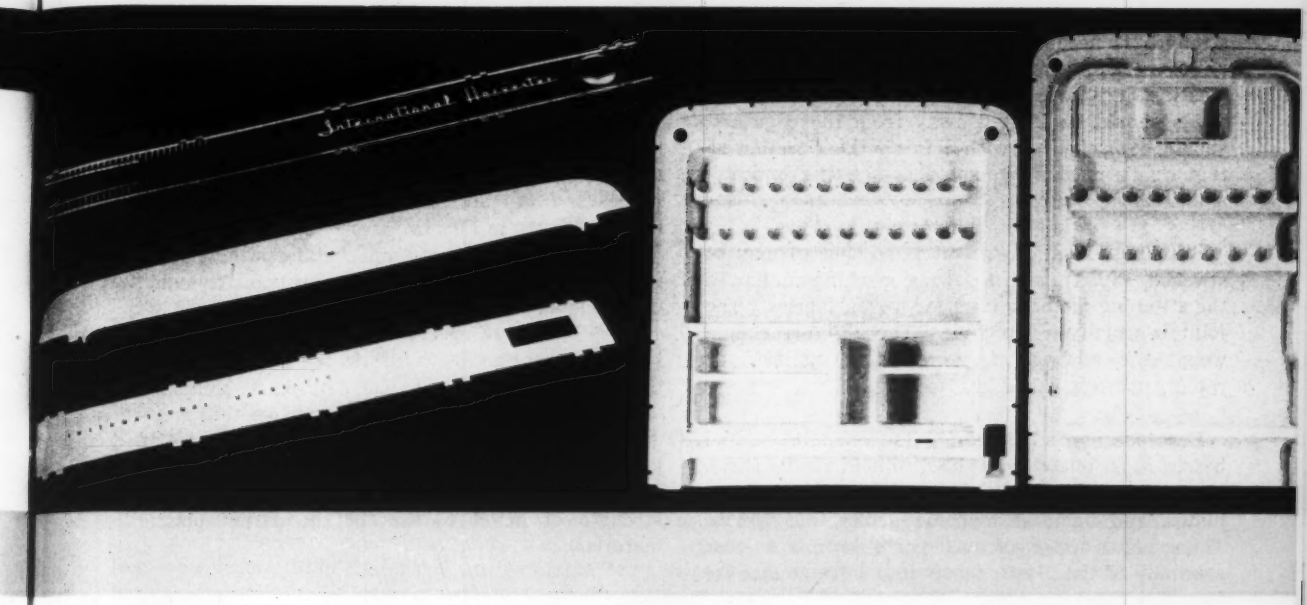
Fig. 1—Typical methods of fastening plastics

FASTENING METHODS

The following design principles related to fastening devices are typical for plastics parts made with either thermosetting or thermoplastic materials.

Screws: Most types of screws are used in fastening plastic parts. Care must be taken to insure dispersion of stresses which can be caused by screw threads or by applying too much torque to the screws. Screws hold tightly and do not permit lateral slippage which may be necessary when two pieces of dissimilar material are fastened together. The coefficient of linear expansion of many plastic materials is ten times that of steel. Two methods of fastening plastic with screws are shown in *Fig.* 2. The mounting method in *Fig.* 2*a* is preferable to 2*b* although both methods can be used if proper design techniques are employed.

Avoid tapping plastic parts for fasteners whenever



possible. Leave ample clearance around the screw for misalignment of parts. Use washers to disperse localized stresses. Large flat plastic parts have a tendency to "oil can" between screws. Insufficient bottom clearances, and improper screw choices, tend to allow screws to loosen if tapped into plastic parts. Cold flow of the plastic material can cause looseness of the screw. Screws are generally more suitable for fastening of thermosetting plastic and reinforced-plastic parts than for thermoplastic resins.

Rivets: Sometimes riveting methods are used in fastening plastic parts. Riveting is more common with the thermosetting plastics, such as phenolics and glass fiber reinforced polyesters, than with the thermoplastic materials.

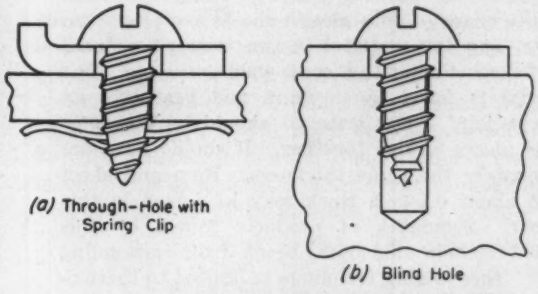


Fig. 2—Two methods of fastening plastics with screws

Standard types of metal rivets may be used if protection is given by means of washers and shoulders to prevent overstressing of the plastic beneath the heads of the rivets. Hollow tubular rivets are commonly used.

General design considerations for riveting plastic parts include use of: large hole tolerances, large rivet heads, surface protection of the plastic, high face area for stress distribution, low riveting pressures.

A family of rivets developed especially for plastic parts includes a push-pin in the center of the rivet which can be used to spread the shaft of the rivet into the lead hole for a tight fit. These rivets may be made of metal or plastic.

Many electrical parts, such as terminal blocks, are commonly riveted. Some plastic toys are riveted. Plastic parts are generally riveted to metal parts and are seldom riveted to other plastic parts.

Spring Clips: Spring type steel nuts are excellent for holding plastic parts in place with a gentle tension. These are commercially available in a wide variety of shapes and sizes. Most spring fasteners permit lateral movement of the plastic part being held but remain locked securely in place as originally pressed into the hole. Typical types of spring clips and applications are illustrated in *Fig.* 3.

Studs: For purposes of mounting, studs can be molded into plastic parts, *Figs.* 1*d*, *e* and *f*. These studs provide an attachment means suitable for pushing on spring clips, lock rings and washers to lock an assembly of parts. Studs may be used for "heat-peening" similar to a metal rivet, *Fig.* 1*d*. Studs are easily broken when the shaft length

exceeds three times the diameter. In case extra strength is needed, the designer can use a drive pin of metal or a more rigid plastic than the parent plastic; the pin is tapered and driven into place. Studs should be located away from the edge and should be backed up with a fairly thick section so that "sink marks" do not show on the opposite side from the stud.

Stitching: Plastic (thin film and sheets) may be stitched, *Fig.* 1*j*, with a sewing machine similar to the stitching methods used for woven fabrics. The joint is usually a lap joint. The designer should weigh the advantages of stitching against the rapidly growing use of heat welding.

Escutcheons and Bezels: Often escutcheons and bezels, *Figs.* 1*e* and *f*, are used to hold plastic parts. Examples include light lenses, horn buttons, nameplates, and business machine grilles and panels. The general design of such parts permits a loose assembly of the plastic insert into a frame and the frame member fastened by means of screws or clips. The designer should be alert to take advantage of the possibility of hiding edges, holes, screws, etc., by means of escutcheons or bezels. A frame around a plastic nameplate is usually considered stylish by designers. Sometimes it is practical to economize by simulating a frame by means of vacuum metallizing the perimeter of the plastic nameplate, thereby making one piece of plastic simulate a two-piece assembly.

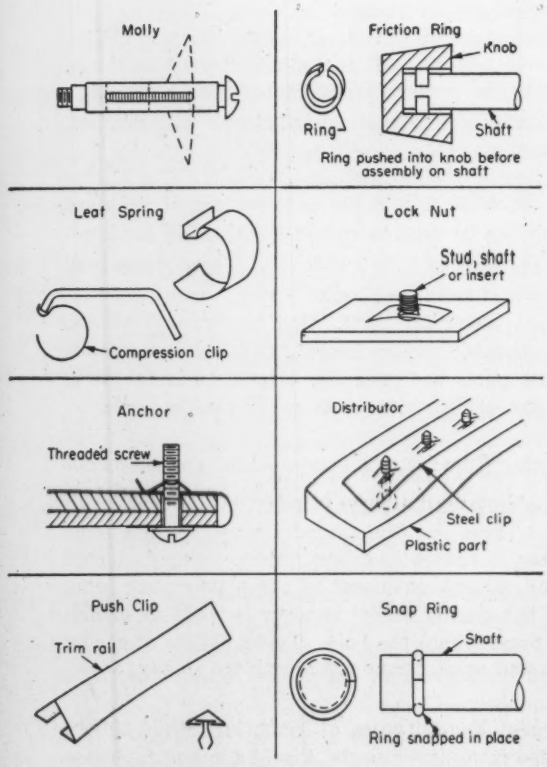


Fig. 3 — Typical types of spring clips and applications

Inserts: Several types of inserts may be used for fastening: (1) stud type (2) pin type (3) screw type (4) splines (5) bushings (6) structural shapes and (7) special load members. A typical insert is shown in *Fig.* 1*h*.

Inserts behave like cores in metal castings. They are generally used in compression or transfer moldings, seldom with other types. The purpose of inserts is to impart special strength-bearing characteristics where needed. Inserts are molded in with the piece, and therefore, are not removable. Care should be exercised by the designer to see that proper face area is specified. Theoretically, the ratio of load-bearing area embedded in plastic to that outside should be in the same proportion as the relative strength of insert to that of the parent plastic material.

Screw Threads: When needed screw threads can be molded or machined in a plastic part. The method used is generally dictated by the molding method, the size of thread and the parent material. Molding threads requires high pressures, and the thread should be fairly large. Molding threads is very economical. Thread cutting on plastic parts is quite common. Application examples include hose nozzles, bolts, mixing valves, telephone sets.

JOINING METHODS

Plastics are more versatile than metals when methods of joining are compared. Plastics may be joined by methods similar to most methods used for joining metals, such as resistance welding, gas welding, adhesives, etc. Plastics may also be joined by all methods used for joining nonmetallic materials. In addition, plastics may be stitched, solvent-bonded, cast-in-place, or molded in two stages.

Electronic Welding: Plastics are good insulators. Therefore, when placed in a high frequency electrical field, the material heats dielectrically. Usually the edges of thin plastic sheets are placed together, and the material is run through a small set of disks similar to a seam-weld operation. The material is fused by pressure and heat into an airtight joint. The material should be the same in the pieces welded together. It should have approximately the same thickness. Film and sheet up to about 0.1-inch thick may be joined in this manner. Examples of products joined by this method include raincoats, beach balls, swimming pools. This joining technique is limited to thermoplastics.

Gas Welding: This joining method is commonly called hot-gas welding because a torch is used

which feeds filler rod of parent material to the work as it heats the joint area. The joint is similar to the metal welding process. The plastic joint can be ground smooth after welding. All thermoplastic materials can be welded in one form or another; polystyrene, polyethylene and vinyl are commonly welded. The plastic will distort unless backed up by a plate. A V-groove is usually ground in the plastic before the weld is filled. The weld is visible after polishing.

Fusing: By a technique known as "flash welding," plastic components are heated, then pressed together and fused. This process is limited to thermoplastics with clean surfaces. Joint strength is not as strong as obtainable with welding and adhesives. Fusing without plastic fill is limited to types of laminating processes for thermoplastic parts and is never used with thermosetting parts.

Adhesive Cements: Adhesives, which are usually less conspicuous than fasteners, are available for both thermosetting and thermoplastic plastics. They will bond plastic to plastic or to other materials. Some pressure is required, and heat is optional. The designer must allow for the maximum possible joint area. Put the adhesive film to work in the best manner so that a peeling action does not occur. Proper surface preparation is essential. Adhesives can be roller coated, knifed, sprayed, brushed, caulked, stamped, silk screened, flocked and dipped. Specify an adhesive which will be compatible with the parent material and the environment during use. Always calculate face area versus load factors with a factor of safety of at least three.

Solvent Bonding: Plastics may be joined by solvent bonding, since plastics are soluable in certain solvents, such as alcohol, methyl ethyl ketone or ethylene dichloride. By applying the solvent to the parts and pressing them together, a bond is achieved. The bond is as strong as the plastic itself. The solvent is colorless and therefore the joints in a transparent part can be clear. Tolerances can be held closely. The solvent is thin and can be applied with a hypodermic needle in nearly inaccessible joint areas. Solvent bonding is usually done with thermoplastics and not thermosets.

Inserts: Inserts represent a method of joining where the plastic is molded around a part which has been processed earlier. Inserts can be plastic or metal. In applications, such as plastic gears, the hub next to the shaft is sometimes a metal insert. In the case of a plastic knob or business-machine key, the designer may want to use a colored plastic insert. This is sometimes called two-stage molding. The knob or key is injection molded leaving a "cored" numeral hollowed out. The part is placed into a mold a second time and the colored plastic injected into the hollow chamber of the number. An example of this technique would be a typewriter key which would have the letter green and the key black. As the key is worn the letter would also wear and the letter would always be clearly visible.

Inserts are actually always joined by shape and position. The designer cannot depend on a strong adhesive bond between the surfaces of the material. Therefore the design should always be predicated on a "locked" shape so the insert will not loosen.

Embedding: There are many occasions when the designer wants to fill an area with plastic for the purpose of sealing for protection against vibration and environment. The usual method is to cast-in-place the components. The plastic shrinks during cure from all directions. Improper design will produce cracks and stresses. Beware of large inserts in small castings. Beware of temperature effects on the coefficient of expansion of the material cast.

The surface of most cast plastics will possess some defects such as bubbles, swirls, mottles. Most castings require a large taper for removal from mold. If the material is cast into elastomeric molds, no taper is required; the mold can be distorted for part removal.

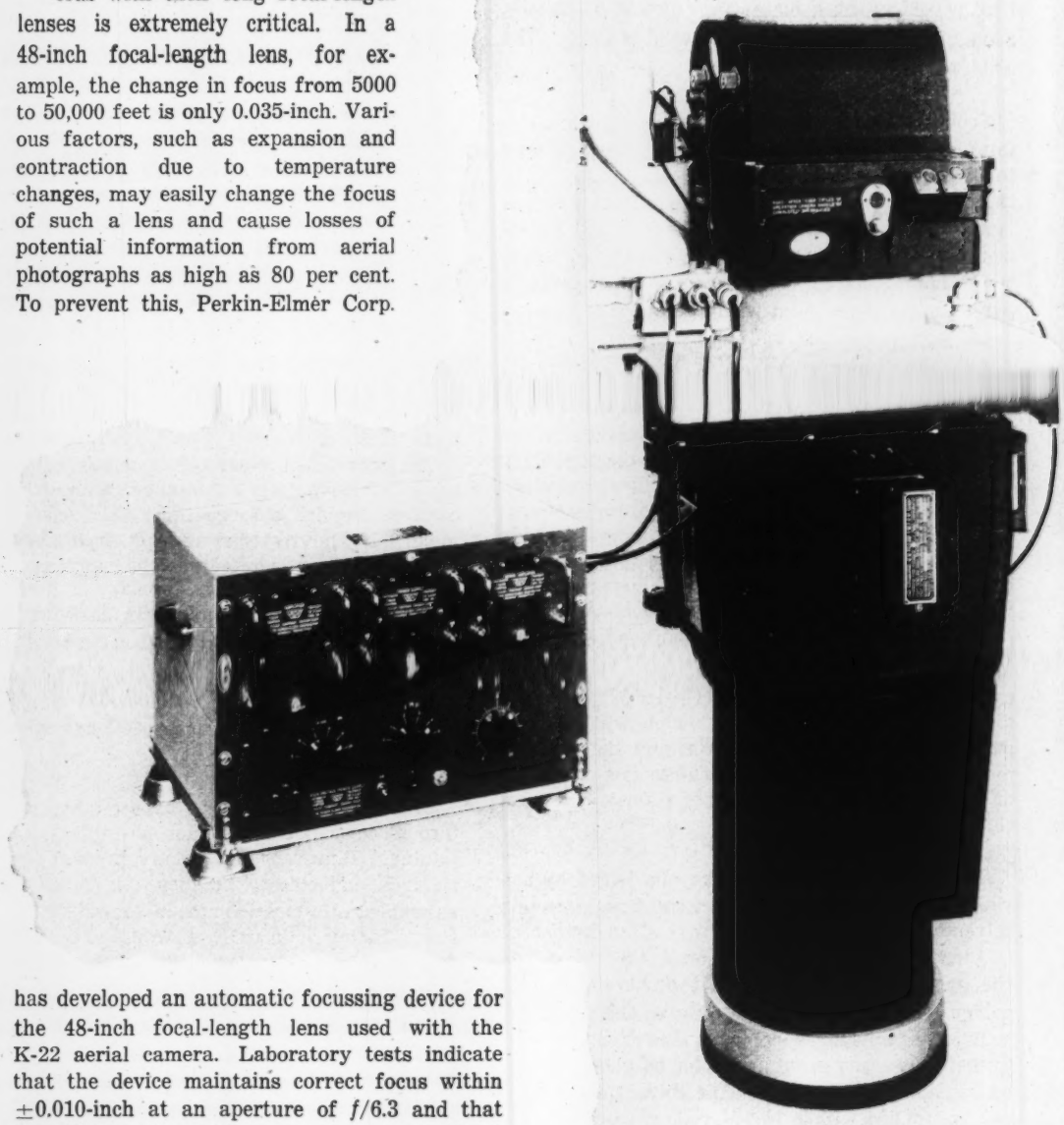
Undercuts must be avoided in castings because of trapped air. The wall sections must be fairly uniform for best curing. Filler may be specified in all casting resins to promote physical properties.

Press Fits: The process of press-fitting plastic into place is not so common as other methods of joining. However, bristles are pressed into plastic hair and clothes brushes, and press pins are assembled into plastic parts in "dowel-pin" fashion. Press fitting is usually a trial-and-error process for initial model work. Press fitting produces stresses which are apt to cause trouble in thermoplastics more than in thermosets.

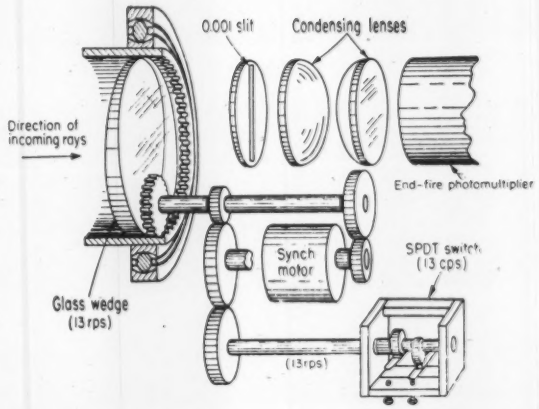
"Our atomic progress—that is to say, whether we are to maintain the advantages of our head start, or fall rapidly behind—will be determined primarily by the numbers of young people who study science and mathematics in our high schools and go on to college to become scientists and engineers in the familiar disciplines. This is true because the nuclear scientist is, first of all, a chemist, a mechanical engineer, a physicist, or a metallurgist whose knowledge is then directed to the field of atomic energy. Those who are responsible for the research and development of atomic energy do not represent a narrow category of "nuclear physicists" or "nuclear engineers." They are drawn from many fields of specialization and together form a team. Nuclear research and development is a sort of chain reaction among many different technical disciplines." — LEWIS L. STRAUSS, *chairman, Atomic Energy Commission.*

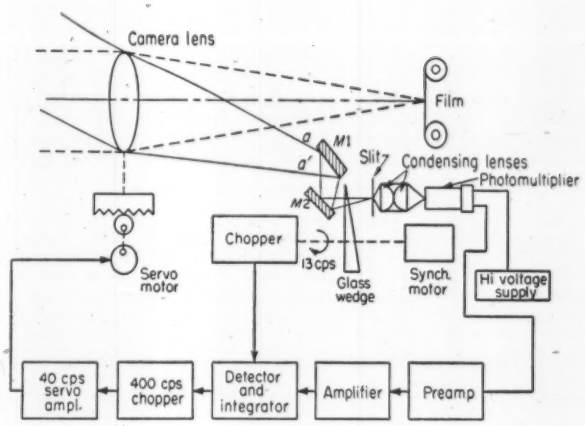
Automatic Device Focusses Aerial Camera

FOCUSSING of large aerial cameras with their long focal-length lenses is extremely critical. In a 48-inch focal-length lens, for example, the change in focus from 5000 to 50,000 feet is only 0.035-inch. Various factors, such as expansion and contraction due to temperature changes, may easily change the focus of such a lens and cause losses of potential information from aerial photographs as high as 80 per cent. To prevent this, Perkin-Elmer Corp. has developed an automatic focussing device for the 48-inch focal-length lens used with the K-22 aerial camera. Laboratory tests indicate that the device maintains correct focus within ± 0.010-inch at an aperture of $f/6.3$ and that focussing is three times as accurate as visual focussing.



Off-axis scanning mechanism consisting of a 1.5-degree rotating glass wedge scans the image projected by the lens. The wedge and a single-pole, double-throw switch are both driven in synchronization at 13 cps. Switch action is such that during one half-cycle of wedge rotation the switch connection is made through one contact





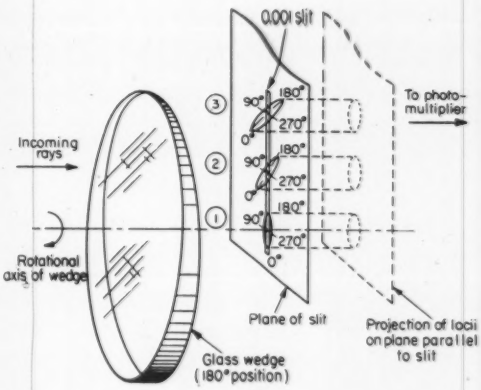
while during the other half-cycle connection is made to the other contact.

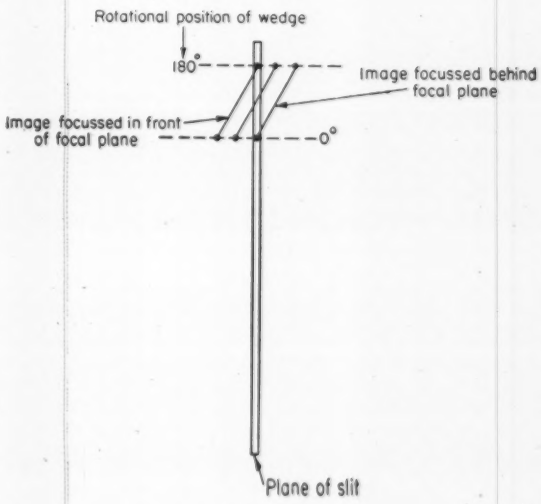
Light passing through the wedge is focussed in the vicinity of a 0.001-inch wide slit which intersects the rotational axis of the wedge. Light passing through the slit then energizes an end-fire photomultiplier tube whose output then charges one of two condensers. The double-throw switch connects the photomultiplier output to one or the other of the condensers during alternate half-cycles of wedge rotation.

An exactly-focussed image causes the beam near the axis of the wedge to be projected onto the plane of the slit as a circle, all portions of which are in focus in the plane of the slit. Beams above the axis are also projected as circles on the plane of the slit. However, the beam is focussed in the plane of the slit only at the 90 and 270-degree points. The beam is focussed behind the plane of the slit at the 180-degree point and in front of the plane of the slit at the zero-degree point.

Since only the light at the zero and 180-degree points passes through the slit to affect the photomultiplier, these are the only portions of the in-focus beam as refracted by the wedge which need be considered. When the image is properly focussed, the intensity of the light at the slit at the zero and 180 degree points is equal, since the points of focus (highest intensity) are equal distances in front and in back of the plane of the slit. When the lens is out of focus, either the zero or 180 degree point moves closer to the plane of the slit, depending upon whether the lens is focussed in front of or behind the focal plane. As this occurs, there is an increase in effective brightness for the point moving closer to the plane of the slit and a decrease in effective brightness of the point being focussed farther from the slit. These differences are converted into electrical signals by the photomultiplier tube and then used to charge the two condensers.

If the image is in focus, the charges on both condensers are equal. When the image is out of focus, charges on the two condensers are not of equal value. This difference or error voltage is fed through a chopper and servo amplifier to drive a servo motor and refocus the lens. A 30-second time lag is built into the system to prevent compensation for transient conditions such as clouds or smoke.





Contemporary Design

Specifying Vulcanized Fiber

VULCANIZED fiber has excellent mechanical strength and good electrical insulating properties. In addition it is easy to form and machine.

Four basic grades of vulcanized fiber are recognized in NEMA specifications:

1. Electrical insulating grade—generally called "fish paper" and used for motor and generator insulation.
2. Commercial fiber—a mechanical and electrical grade for general-purpose applications.
3. Bone fiber—an exceptionally hard, dense grade used where close machining tolerances are specified or where unusual wear or abrasion will be encountered.
4. Trunk and case fiber—a tough, abrasion-resistant surfacing material for plywood.

In addition, many variations of these four basic grades have been developed to meet special requirements. Vulcanized fiber is available in the form of sheets, strips, rolls, coils, rods, tubes and special shapes.

Mechanical Specifications: Vulcanized fiber has a tensile strength range of 6000 to 12,000 psi, depending upon the grade. Flexural strength limits are 12,000 to 20,000 psi. Compressive strength is 20,000 to 30,000 psi, and shear strength 11,000 to 15,000 psi. In addition, impact strength is 4 to 8 ft-lb per in., Rockwell hardness is 60 to 100, and modulus of elasticity is 750,000 psi. Density is 1.0 to 1.5 gram per cu cm, or 0.036 to 0.054 lb per cu in. Dielectric strength is 150 to 250 v per mil for short time test with ⅛-in. thickness.

Vulcanized fiber is impervious to most non-aqueous liquids, including gasoline, oil and other petroleum products, as well as most organic solvents.

Electrical Specifications: Vulcanized fiber has a power factor of 0.03 to 0.08 and a dielectric constant of from 4 to 7 in terms of 1000 kc. It is one of the most arc-resistant of the available plastic insulating materials. It emits a neutral or uncharged gas under the heat of the arc.

Formability: Relatively thin sections of vulcanized fiber can be readily curved, bent and deep-drawn without sacrificing strength.

Plasticity of wet vulcanized fiber is such that the material can be stretched as much as 25 per cent and compressed by about 50 per cent. This means that a 3-inch circular disk can be drawn to a cup 1½ in. diameter and about 1⅛ in. deep. For a part roughly cubical in shape, depth of draw should be about one-third the length of the diagonal of one face. Depth of a spherical draw, as in the crown of a protective helmet, can be approximately one-half the average diameter of the opening.

While fiber of all thicknesses can be formed, considerable attention must be given to radii of bends and to depth of draw in the thicker materials. For parts that have sharp curvatures, the material should be 1/16 to 3/32-in. thick to permit a good draw and, at the same time, provide the necessary strength and rigidity in the finished part.

Although dry vulcanized fiber is essentially a thermoset material below 250 F, it becomes moderately thermoplastic if heated to about 350 F. At this temperature it can be postformed into relatively simple shapes, but extent of draw or bend obtainable with heat alone is considerably less than that possible when the fiber is wetter.

In general, vulcanized fiber and the laminated phenolics have similar postforming properties. Since little distortion occurs in the hotforming of simple shapes, a fiber blank can be otherwise completely fabricated prior to forming.

Dry vulcanized fiber can also be swaged by forcing it into die cavities under high pressure, usually with some heat.

Machinability: Vulcanized fiber can be sawed, drilled, milled, turned, punched, sheared and otherwise machined as easily as brass or wood. It can be cut with a circular saw to provide smooth edges and close tolerances, or with a band saw when the finish of the cut surface is not critical.

Vulcanized fiber can be milled with high-speed tungsten carbide or Carboloy-tipped tools. Fiber may also be threaded on an engine lathe, and this method is recommended for fine threads.

The material can be punched easily. Compound dies are recommended for intricate pieces and progressive dies for high-speed fabrication. Punches must be made oversize for hot punching since the fiber shrinks during cooling. Cold punching produces good edges on ¼-in. stock, but thicker stock should be heated to about 180 F.

The material lends itself to finishing with enamels or lacquers. It can be sanded or buffed to a glass-smooth finish or embossed for decorative effects.

Information for this article supplied through the courtesy of National Vulcanized Fibre Co., Wilmington, Del.

A simplified approach for determining power losses and efficiency of

Planetary Gear Drives

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IN A PLANETARY gear drive, the power circulating within the system elements may differ appreciably from that being transmitted. This unique characteristic, which is a result of the relative motion of the gear members, is present in some degree in all planetary gear trains and has a significant effect on the performance and efficiency of systems transmitting power continuously. Power losses become a function of the power developed in the gearing rather than of the actual power transmitted through the train.

Several methods for determination of power losses and efficiencies of planetary gearing have been proposed, and expressions for a number of specific gear arrangements have been developed. Most of these analyses are based on the principle of equilibrium of moments first suggested by Massot.[1]

This article presents a new approach to the problem and offers a general method of solution, utilizing the concept of an "equivalent" conventional gear train in conjunction with the particular kinematic characteristics of planetary systems. Several representative planetary gear arrangements are analyzed to illustrate application of the principles discussed.

Basic Considerations: Certain general concepts of gear performance will be useful in analysis of planetary gear systems and perhaps should be reviewed.

[1]References are tabulated at end of article.

Nomenclature

d = Pitch diameter of gear, in.
e = Efficiency of planetary gear pair
e_t = Overall efficiency of planetary gear train
F = Tangential force acting at the pitch circle of the driving gear, lb
L = Tooth mesh power loss in a planetary gear pair, ft-lb per sec
L_t = Total tooth mesh power loss in a planetary gear train, ft-lb per sec
l = Tooth mesh loss in a conventional gear pair, ft-lb per sec
l_t = Total tooth mesh loss in a conventional gear train, ft-lb per sec
m = Speed ratio of gear pair
m_p = Overall speed ratio of planetary gear train
n = Number of meshing pairs in a gear train
P_i, P_o = Input and output power, respectively, ft-lb per sec
R = Planetary velocity ratio defined by Equation 6
v = Pitch-line velocity of gear pair, fps
v_e = Velocity of engagement of a gear pair, fps
Δ = Ratio of tooth mesh loss to input power in a gear pair
η = Efficiency of conventional gear pair
η_t = Overall efficiency of conventional gear train
ω = Angular velocity, radians per sec

XUM

The tooth mesh loss in a pair of gears with fixed centers is

$$l = \Delta F v = \Delta P_i \qquad (1)$$

where symbols are defined in *Nomenclature*. The efficiency of a drive system consisting of one such pair of gears is

$$\eta_t = \eta = \frac{P_o}{P_i} = \frac{P_i - l}{P_i} = 1 - \Delta \qquad (2)$$

For a train with more than one pair of gears,

$$\eta_t = \eta_1 \eta_2 \ldots = (1 - \Delta_1)(1 - \Delta_2) \qquad (3)$$

where subscripts 1 and 2 identify individual meshing pairs in the train. If $\Delta_1 = \Delta_2 \ldots = \Delta_n = \Delta$, then

$$\eta_t = (1 - \Delta)^n = \eta^n \qquad (4)$$

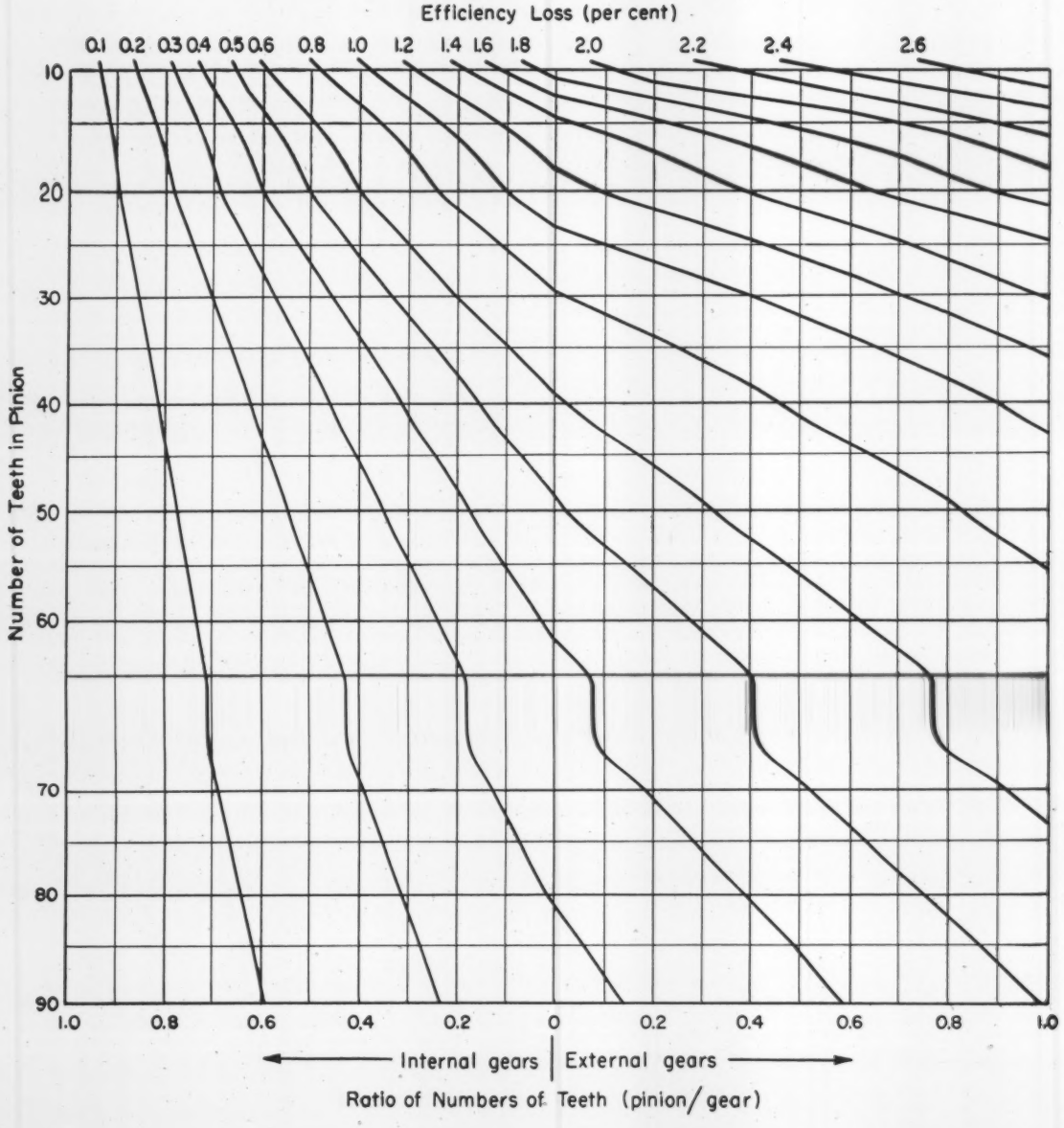
Principal contributing sources of power losses in gear trains are as follows:

1. Sliding friction between meshing tooth surfaces.
2. Oil churning.
3. Friction in shaft support bearings.

Tooth mesh loss, as the first type will be called here, depends upon the geometry of tooth profiles and upon a "mean coefficient of friction" between the mating surfaces. This mean coefficient of friction is a function of the acting tooth forces, gear material, contact surface condition, and the velocity of relative motion of these surfaces in the different phases of engagement. The last factor is also a function of geometry of the gearing.

Although analytical expressions have been developed for determination of tooth mesh loss, the relationships involved are rather complex and not always reliable. They appear to be best suited for comparative evaluation of different gear-tooth forms rather than for calculation of

Fig. 1 — Efficiency losses from sliding friction between a pair of full-depth 20-degree spur gears of British standard form. Losses vary negligibly for different tooth forms and pressure angles


Efficiency Loss (per cent)
0.1 0.2 0.3 0.4 0.5 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6
10 20 30 40 50 60 70 80 90
Number of Teeth in Pinion
1.0 0.8 0.6 0.4 0.2 0 0.2 0.4 0.6 0.8 1.0
Internal gears
External gears
Ratio of Numbers of Teeth (pinion/gear)

absolute values of gear losses. Available experimental data offer a more reliable source of information on tooth mesh power losses in gears than do the theoretical expressions. The following conclusions can be made:

1. Tooth mesh losses in internal gears are somewhat less than those in external gears.

2. Pitch-line velocity has small influence on gear efficiency.

3. With the exception of light load conditions, it may be assumed that the ratio, Δ, of tooth mesh loss to input power does not depend upon this power.

4. The difference in losses for several standard tooth forms in common use is so small that the same values of efficiency may be assumed for various tooth forms.

5. Losses from oil churning are independent of the load transmitted, but depend upon gear velocities, gear-drive design, and viscosity of lubricants. It seems that these losses can be neglected for gear trains which transmit relatively large power, but must be taken into account in the total efficiency of high-velocity, low-power gear systems.

6. For practical purposes, the loss in a pair of spur gears may be assumed to be proportional to the product of the pitch-line velocity and the tangential force acting at the pitch circle of the driving gear.

Merritt[2] has developed a chart, *Fig.* 1, which gives the value of Δ for external and internal gear pairs as a function of the speed ratio of the two gears. In this chart, the abscissas represent the ratios between the numbers of teeth on pairs of gears; the numerator of the ratio is always the number of teeth on the smaller gear. Range of chart values includes pinions varying in size from 10 to 90 teeth. Plots are based on the sliding friction between a pair of spur gears of British Standard form having 20-degree pressure angle and full depth. A mean coefficient of friction equal to 0.08 is assumed. *Fig.* 1 may be used for a first approximation in calculation of efficiency of gear trains, if more pertinent data are not available. The chart values include loss for ball or roller bearings.

Equivalent System Concept

Tooth mesh loss of a pair of gears in a planetary train depends upon the same factors as for a pair of gears with fixed centers. Here, also, it can be assumed that the loss in engagement is proportional to the product of the tangential force at the pitch circle of the driving gear and the velocity of engagement:

$$L = \Delta F v_e \qquad (5)$$

The essential difference between Equations 1 and 5 is in the magnitude of the velocity of engagement. In a conventional gear train with fixed axes of gear rotation, v_e is equal to pitch-line velocity v of the gear, and the maximum limit of the product Fv is equal to the input power of the train. In a planetary gear train, however, the velocity of engagement is affected by the relative motion of the planet cage. Thus, velocity of engagement

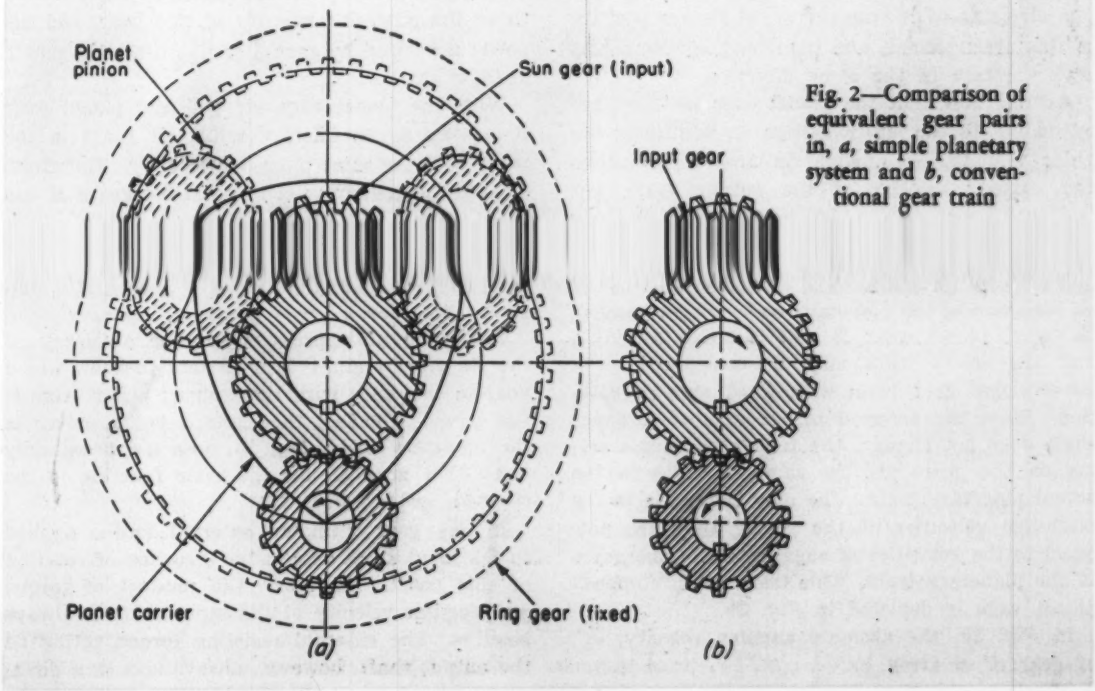


Fig. 2—Comparison of equivalent gear pairs in, *a*, simple planetary system and *b*, conventional gear train

v_e is not equal to pitch line velocity v; and product Fv_e is not equal to the input power at the driving gear of the pair.

For comparison, two gear pairs will be considered, *Fig.* 2: one in a planetary gear train, the other in a conventional train. Assume that the geometry, size, and other characteristics of the corresponding gears are the same. Tangential forces F acting on both gear pairs are equal, and the pitch-line, or absolute, velocity of the sun gear in the planetary train is the same as that for the corresponding gear in the conventional train.

The ratio of tooth mesh losses in these "equivalent" gear pairs is

$$\frac{L}{l} = \frac{\Delta F v_e}{\Delta F v} = \frac{v_e}{v} = R \quad \ldots\ldots (6)$$

where R is defined here as the planetary velocity ratio. Therefore, the tooth mesh loss in a pair of gears in a planetary train is

$$L = lR = \Delta F v R = P_i \Delta R = P_i R\ (1 - \eta) \quad \ldots\ldots (7)$$

where l is the loss in an equivalent gear pair with fixed centers and the same input power as the planetary pair, *Fig.* 2.

The efficiency of this planetary gear pair is given by

$$e = \frac{P_o}{P_i} = \frac{P_i - L}{P_i} = 1 - \Delta R = 1 - R(1 - \eta) \quad (8)$$

This same method may be applied for determining losses in any planetary gear pair and, consequently, for determining the efficiency of the entire planetary train.

Simple Planetary Train

This method may be best illustrated by an example. Consider the simple planetary gear train, *Fig.* 2*a*, which is represented schematically in *Fig.* 3*a*. This system is one of the most compact planetary gear arrangements having a wide range of application possibilities in design. Design of an actual planetary train of this type is shown in *Fig.* 4. In this train, *Fig.* 3*a*, planet gear B engages simultaneously with sun gear A, which is keyed to input shaft D, and with fixed internal (ring) gear C. Planet gear B rotates freely around its own axis on a shaft mounted to the planet cage, G, which is keyed to and drives output shaft H.

The speed ratio of this train is

$$m_p = \frac{\omega_D}{\omega_H} = \frac{\omega_A}{\omega_G} = 1 + \frac{d_C}{d_A} \quad \ldots\ldots (9)$$

where subscripts identify the corresponding system elements. The value of m_p is always positive in this arrangement, and input and output shafts always rotate in the same direction.

Assume now that the planet cage is "stopped" by adding to the entire system an additional angular velocity, $-\omega_H$, equal in absolute value to the angular velocity of the output shaft, but opposite in direction. The relative motions of all members of the planetary train are unchanged. However, planet gear B now becomes an idler, and the entire train may be considered as a conventional gear train with fixed axes of rotation. Since the external torque applied to input shaft does not change, the tangential forces acting on the gears are the same as those in the actual planetary train. The only change is in the pitch-line velocities of the gears; they are now equal to the velocities of engagement of the gears in the planetary train. This train with "stopped" planet cage is depicted in *Fig.* 3*b*.

In *Fig.* 3*b*, the absolute angular velocity, ω_A', of gear A' is given by

$$\omega_A' = \omega_A + (-\omega_H) = \omega_A - \frac{\omega_A}{m_p} = \omega_A \left(1 - \frac{1}{m_p}\right) \quad \ldots\ldots (10)$$

Velocity ω_A', which is the pitch-line velocity of gear A', is thus also the velocity of engagement of gear A in *Fig.* 3*a*. Since the value of m_p for this planetary train is always greater than one, the value of ω_A' is always positive if ω_A is positive. The planetary velocity ratio, R_{AB}, for gears A and B is

$$R_{AB} = \frac{\omega_A'}{\omega_A} = \frac{\omega_A \left(1 - \frac{1}{m_p}\right)}{\omega_A} = 1 - \frac{1}{m_p} \quad \ldots\ldots (11)$$

This result means that the velocity of engagement of gear A in the planetary train, *Fig.* 3*a*, is R_{AB} times the pitch-line velocity of this gear, and the power developed by gear A is R_{AB} times the power at input shaft D.

With the planet cage stopped and planet gear B serving as an idler, *Fig.* 3*b*, all gears in the train have the same pitch-line velocity. Therefore, R_{BC}, the planetary velocity ratio for gears B and C, is equal to R_{AB}, and $R_{AB} = R_{BC} = R$ is a constant value for a given planetary train.

To derive an expression for the efficiency of the planetary train, it is important to know which gear in the train with the stopped planet cage is the driver. The fact that gear A is the driver in the planetary train, *Fig.* 3*a*, does not necessarily mean that gear A' has the same function in the stopped system, *Fig.* 3*b*.

In any gear train, an external torque applied to the input shaft acts in the direction of rotation of this shaft. Therefore, the product of torque and angular velocity at the input shaft is always positive. The external resisting torque acting on the output shaft, however, always acts in a direc-

tion opposite to that of shaft rotation. Therefore, the product of external torque and angular velocity for the output shaft is always negative.

For the present case, *Fig.* 3, let it be assumed that ω_D, ω_D', and the external torque acting on shaft D' all have positive values. Thus, the product of torque and angular velocity at shaft D' is positive, and gear A' is the driver. In this instance, the position of the driving gear is the same in both trains, *Figs.* 3*a* and *b*.

The power, P_{AB}', developed between gears A' and B' in the equivalent train, *Fig.* 3*b*, is: $P_{AB}' = P_i R$. Equal power is developed by gears A and B, *Fig.* 3*a*. If the tooth mesh loss ratio for gears A' and B' is Δ_1, and the for gears B' and C' is Δ_2, the power delivered at output shaft H' is

$$P_{H'} = P_i R (1 - \Delta_1)(1 - \Delta_2) = P_i R \eta_t \quad \ldots\ldots (12)$$

where η_t = the overall efficiency of a conventional gear train consisting of the same gears as the planetary train. Therefore, in the planetary train and its equivalent, which have equal losses,

$$L_t = P_i R - P_i R \eta_t = P_i R (1 - \eta_t) \quad \ldots\ldots (13)$$

The efficiency of a planetary train of this type is

$$e_t = \frac{P_i - L_t}{P_i} = \frac{P_i - P_i R (1 - \eta_t)}{P_i} =$$

$$1 - R (1 - \eta_t) \quad \ldots\ldots (14)$$

From Equations 11 and 14

$$e_t = 1 - (1 - \eta_t)\left(1 - \frac{1}{m_p}\right) \quad \ldots\ldots (15)$$

Ring gear C is always larger than sun gear A so that the value of R for this planetary train is always smaller than one but larger than 0.5.

The tooth mesh losses in this train, then, are smaller than, but not less than half, the tooth losses in a conventional train consisting of the same gears. Consequently, the efficiency of this type of planetary train is always higher than the efficiency of a corresponding conventional train but lower than the efficiency of one pair of gears with fixed centers and the same unit tooth mesh loss ratio, Δ.

Generally speaking, this efficiency may be considered as highly satisfactory for planetary gear

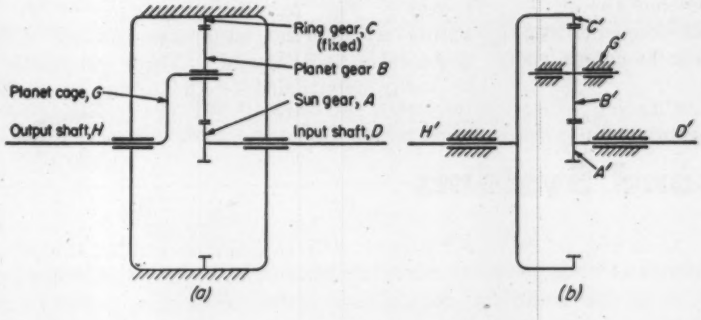


Fig. 3—Simple planetary gear system showing, *a*, schematic arrangement of system elements and, *b*, equivalent system obtained by "stopping" the planet cage. Prime notations identify corresponding members

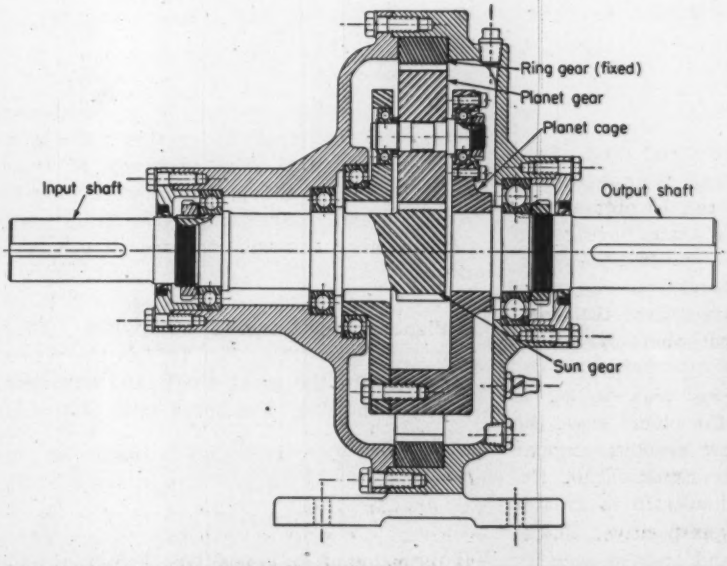


Fig. 4—Typical planetary gear transmission design employing the basic arrangement shown in *Fig.* 3*a*

systems. However, this type of train can be designed only for relatively small speed ratios.

Sample Calculations: A planetary gear train of the type shown in *Fig.* 3 has the following design data: $d_C = 12$ in., $d_A = 2$ in., $d_B = 5$ in., and $m_p = 7$. For gears A and B, efficiency $\eta_1 = 0.98$, and for gears B and C, $\eta_2 = 0.99$.

The efficiency of a conventional train with the same gears is $\eta_t = \eta_1 \eta_2 = 0.9702$. For the planetary train, *Fig.* 3*a*, using Equation 11, $R_{AB} = R_{BC} = R = 1 - (1/7) = 6/7$. From Equation 14, $e_t = 1 - (6/7)(1 - 0.9702) = 0.97446$. In this case, the velocity of engagement in the planetary train is somewhat less than that in a corresponding conventional train consisting of the same gears and having the same angular velocity and power at the input shaft. Since the tangential forces acting on the gears are the same, the power developed by the planetary gears is lower than in the conventional train. Dynamic tooth loads and wear, which depend upon the tangential force and the velocity of engagement, are also lower in the planetary train.

Modified Train Arrangement: A planetary gear train similar to the one just considered, but with gear A as the fixed member, is shown schematically in *Fig.* 5. Internal gear C becomes the driver, and output shaft H is connected to planet cage G. The speed ratio of this train can be determined from the following relationship:

$$m_p = \frac{\omega_D}{\omega_H} = \frac{\omega_C}{\omega_G} = 1 + \frac{d_A}{d_C} \qquad (16)$$

After the angular velocity $-\omega_H$ is added to the entire system, as in the previous analysis, the angular velocity of gear C becomes

$$\omega_C' = \omega_C + (-\omega_H) = \omega_C \left(1 - \frac{1}{m_p}\right) \qquad (17)$$

The value of m_p is always positive and greater then one; therefore, the direction of ω_C' is positive if ω_C is positive. The torque acting on input shafts D, and D', is also positive. Thus, the product of torque and angular velocity for gear C' will also be positive, making this gear the driver in the train with the stopped planet cage.

Planetary velocity ratio, output power, tooth mesh loss and efficiency for this train can be determined from Equations 11 to 15. There is a difference, however, in the value of R. In this train, R is always smaller than 0.5. Therefore, the efficiency of this train is considerably higher than that of a conventional train with comparable gear arrangement. Here again, however, the speed ratios possible with trains of this type are relatively small.

Other combinations of fixed, input and output members are also possible with the basic system shown in *Fig.* 2*a*. Each arrangement will constitute a different mechanism having different speed ratio and efficiency. These efficiencies may be easily determined by the foregoing method.

Compound Systems

The speed ratio of a planetary train can be increased by using the so-called compound arrangement shown schematically in *Fig.* 6. In this train, sun gear A is connected to input shaft D. Output shaft H is connected to planet cage G which carries planet gears B and J. Planet gear J engages the fixed ring or internal gear, C. Speed ratio of this train is

$$m_p = \frac{\omega_D}{\omega_H} = 1 + \frac{d_C d_B}{d_A d_J} \qquad (18)$$

This expression shows that the speed ratio which can be obtained through this train is approximately of the same magnitude as can be obtained by means of a conventional gear train having two pairs of gears.

Assume that input shaft D revolves clockwise. The speed ratio m_p is always positive; therefore, the angular velocity of output shaft H, $\omega_H = \omega_A/m_p < \omega_A$, is also positive.

When angular velocity $-\omega_H = -\omega_A/m_p$ is added to the system to stop the planet cage, the value of ω_A' which is the new absolute angular velocity of gear A is given by Equation 10. Because the value of m_p for this train is greater than one, ω_A' is positive if ω_A is positive. Therefore, the product of torque and angular velocity for gear A' will be positive, making this gear the driver in the train with the stopped cage.

Following the same reasoning, it can be shown that the expression for efficiency for this planetary train is the same as for the previous two types (Equation 14). The difference lies in the value of R. For this train,

$$R = \frac{\omega_A'}{\omega_A} = 1 - \frac{1}{m_p} = \frac{d_C d_B}{d_A d_J + d_C d_B} \qquad (19)$$

It can be seen that R for this train is always smaller than one. The efficiency of this train must therefore be somewhat higher than that of a comparable conventional gear train consisting of two gear pairs with the same tooth mesh loss ratios.

Planetary Differential: A typical differential planetary gear train, *Fig.* 7*a*, has the planet cage connected to the input shaft, and sun gear K is a driven member. The speed ratio of this train is

$$m_p = \frac{\omega_D}{\omega_H} = \frac{1}{1 - \dfrac{d_A d_J}{d_B d_K}} = \frac{d_B d_K}{d_B d_K - d_A d_J} \qquad (20)$$

If the value of m_p is positive, the output and input

shafts rotate in the same direction. If m_p is negative, they revolve in opposite directions. The most interesting peculiarity of this train is that a speed ratio of any magnitude, even infinity ($\omega_H = 0$), can theoretically be obtained.

The efficiency of this train may be determined by the methods discussed previously. Assume that input shaft H revolves in a clockwise (positive) direction and $d_A d_J / d_B d_K < 1$ so that $m_p > 1$ and is positive. To stop planet cage G, let the entire system be revolved at an angular velocity, $-\omega_D$. With the planet cage stopped, the absolute angular velocity of gear K becomes

$$\omega_K' = \omega_K + (-\omega_D) = \frac{\omega_D}{m_p} - \omega_D = -\omega_D \left(1 - \frac{1}{m_p}\right) \quad (21)$$

For the assumed conditions, the value of ω_K' is negative. Actually, in the planetary train, *Fig. 7a*, gear K has a positive direction of rotation and, being connected to the output shaft, is loaded by an external torque acting in a direction opposite to its motion. Thus, the external torque acting on shaft H and gears K and K' is negative. The product of negative angular velocity and negative torque is positive. Therefore, gear K' is the driver in the equivalent train obtained by stopping the planet cage.

This case is an example of an interesting peculiarity in analysis. The gear that must be considered as the driver for analysis of train performance is actually connected to the driven shaft of planetary train and appears, at first, to be a driven member. Consequently, with the planet cage fixed, gear A' becomes the driven member. Now the expression for efficiency may be derived. If the power at output shaft H of the planetary train is P_o, the power developed in the engagement of gears J and K is $P_o R$. Since gear K' is considered as the driver, the tooth mesh loss in this train is

$$L_t = P_o R (1 - \eta_t) \quad (22)$$

Efficiency of the train is

$$e_t = \frac{P_o}{P_o + P_o R(1 - \eta_t)} = \frac{1}{1 + R(1 - \eta_t)} \quad (23)$$

Planetary velocity ratio R is

$$R = \frac{\omega_K'}{\omega_K} = \frac{-\omega_D \left(1 - \frac{1}{m_p}\right)}{\frac{\omega_D}{m_p}} = -(m_p - 1) \quad (24)$$

The value of R is negative. This result means that the motion of gear K relative to gear J in this planetary train is opposite in direction to the absolute velocity of gear K. However, the direction of relative rotation does not influence the magnitude of tooth mesh loss in the gear pair. Therefore, the absolute value of R must be used in the calculation of train losses and efficiency. Introducing this value into Equation 23 gives

Fig. 5—Simple planetary gear train in which the sun gear is the fixed member. This train is a modification of the arrangement shown in *Fig. 3a*

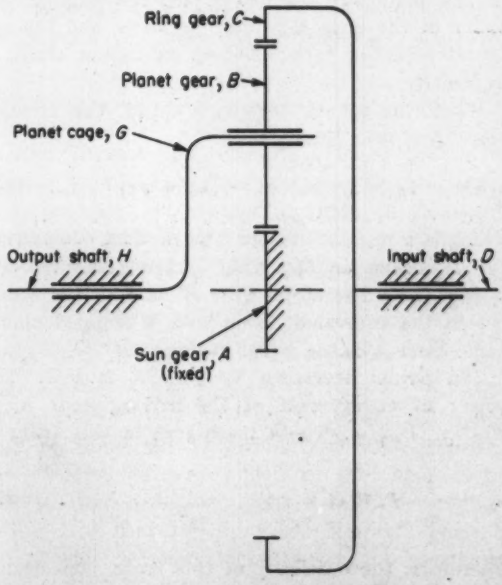
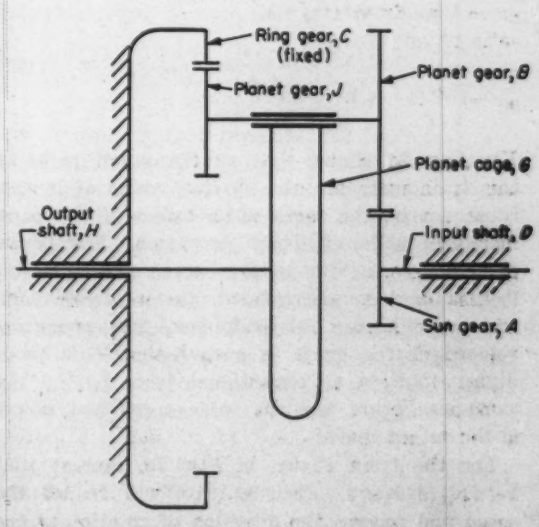


Fig. 6 — Compound planetary gear train for large speed ratios



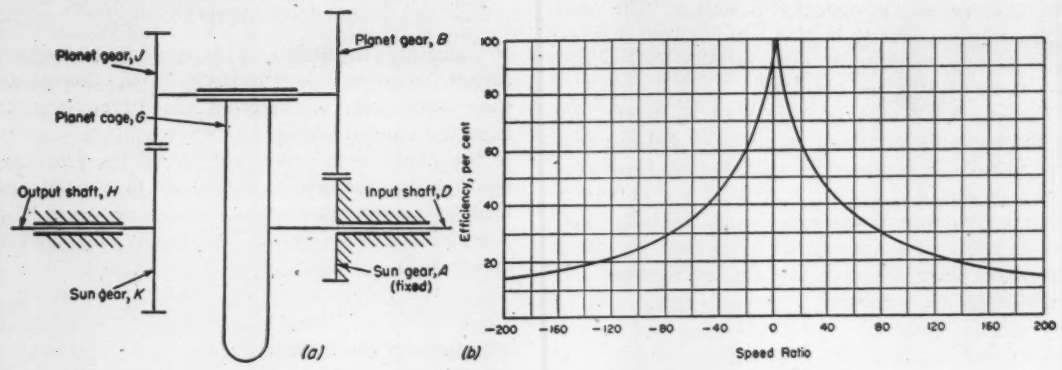


Fig. 7—Basic differential planetary gear system showing, *a*, arrangement of system elements and, *b*, relationship between efficiency and speed ratio

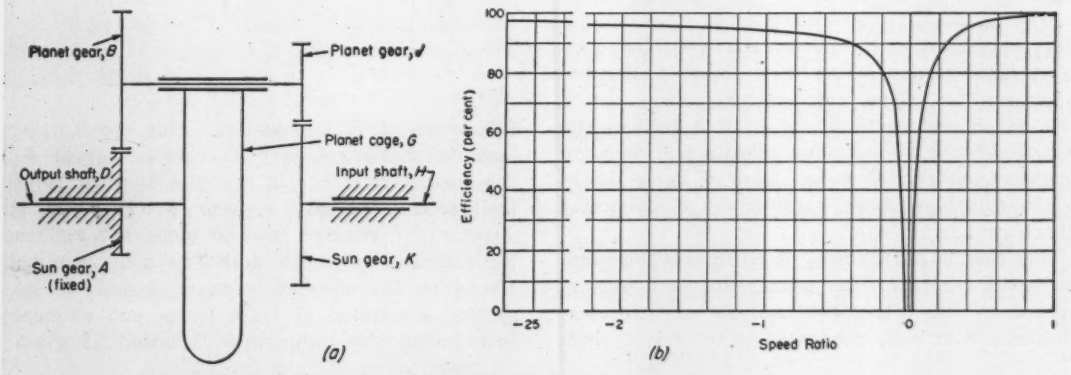


Fig. 8—Differential planetary gear system showing, *a*, arrangement of system elements and, *b*, relationship between efficiency and speed ratio. This train is basically the same as the one shown in *Fig. 7a* except that direction of power flow has been reversed

$$e_t = \frac{1}{1 + (1 - \eta_t)(m_p - 1)} = \frac{1}{1 + (1 - \eta_t)\left(\dfrac{d_A d_J}{d_B d_K - d_A d_J}\right)} \quad \ldots\ldots (25)$$

Equation 25 shows that as the speed ratio of this train increases, the absolute value of R and, consequently, the tooth mesh losses in the train increase, while efficiency decreases. For trains of this type, having a large speed ratio, the velocities of gear engagement are relatively high and the efficiency relatively low. The power developed at the gears in such trains is R times higher than in a conventional train having the same size gears and the same speed and power at the *output* shaft.

For the train shown in *Fig. 7a*, assume that $1 < d_A d_J / d_B d_K < 2$. Such a train will reduce the speed and reverse the direction of rotation of the output shaft, so that m_p is now negative with an absolute value greater than one (Equation 20).

In the planetary train, *Fig. 7a*, the angular velocity of the gear K is now negative, and the external resisting torque acting on output shaft H is positive.

When the planet cage is stopped, the angular velocity of gear K becomes

$$\omega_{K'} = -\omega_K + (-\omega_D) = -(\omega_K + \omega_D) \quad \ldots\ldots (26)$$

which is a negative value. The product of external torque acting on this gear and angular velocity is negative. Therefore, gear K' is a driven member in the equivalent train with a stopped planet cage. Gear A' is the driver in this case.

The power developed by gear K is $P_o R$. The power of engagement of the driving gear A' is $P_{AB'} = P_o R/\eta_t$. Tooth mesh loss in this train is

$$L_t = \frac{1}{\eta_t} P_o R (1 - \eta_t) \quad \ldots\ldots (27)$$

Therefore, the efficiency of this train, considering tooth mesh loss only, is

$$e_t = \frac{P_o}{P_o + \frac{1}{\eta_t} P_o R (1 - \eta_t)} = \frac{\eta_t}{\eta_t + (1 - \eta_t) R} \quad (28)$$

The value of R for this train is given by

$$R = \frac{\omega_K'}{\omega_K} = \frac{-(\omega_K + \omega_D)}{\omega_K} = -(1 - m_p) \quad (29)$$

The absolute value of R must be used in Equation 28 for efficiency calculations.

Sample Calculations: A planetary differential train. *Fig. 7a,* has the following design data: $d_A d_J / d_B d_K = 1.025$ and $\eta_t = 0.97$. From Equation 20, $m_p = -40$; from Equation 29, $R = -41$; and from Equation 28, using the absolute value of $R = 41$, $e_t = 0.4409$. In a planetary gear train of this type with $P_o = 1$ hp, the power developed by gears J and K is more than 41 hp while that developed by gears A and B is 41/0.97 = 42.26 hp. These conditions must be taken into account when designing gears for the planetary train.

The relationship between efficiency and speed ratio for the differential planetary gear train, *Fig. 7a,* is shown in *Fig. 7b.* The left-hand portion of the curve represents the cases where speed ratio is negative, and the right-hand portion those with positive speed ratios. When $m_p = +1$, the entire system is revolving as one unit, without relative motion of its parts, and $e_t = 1$ or 100 per cent. Actually, however, such a ratio is not possible in practice because it requires that $d_A d_J / d_B d_K = 0$. When, $m_p = -1$, the absolute value of $R = 2$, and the losses in this train are about twice as large as in a conventional train consisting of the same gears.

The chart indicates that efficiency of this type of planetary train decreases rapidly with the increasing speed ratio, and that gears in trains having large speed ratios operate under extremely severe service conditions. Apparently, trains of this type are most suitable for applications where speed ratio or power transmitted are relatively low.

Reversed Power Flow: If, in the train depicted in *Fig. 7a,* the sun gear K is made the input member and the shaft connected to the planet cage becomes the output member, a different mechanism will be obtained, *Fig. 8a.*

The speed ratio of this modified train is

$$m_p = 1 - \frac{d_A d_J}{d_B d_K} \quad (30)$$

The value of m_p is positive or negative depending upon the value of $d_A d_J / d_B d_K$. Assume input shaft H, connected to gear K, revolves clockwise. The external torque applied to this shaft acts in a positive direction. Assume also, that $d_A d_J / d_B d_K < 1$ so that $1 > m_p > 0$. This arrangement will provide a speed increase without reversing the direction of rotation. A positive speed ratio greater than one is theoretically impossible for this train, because it requires the value of $d_A d_J / d_B d_K$ to be less than zero.

To "stop" planet cage G, it will be necessary to revolve the entire system at an angular velocity, $-\omega_G$. Then, the angular velocity of gear K becomes

$$\omega_K' = \omega_K + (-\omega_G) = \omega_K - \frac{\omega_K}{m_p} = -\omega_K \left(\frac{1}{m_p} - 1 \right) \quad (31)$$

For the assumed conditions, the value of ω_K' is negative. Therefore, the product of positive torque and negative angular velocity is negative, and gear K' will be a driven member in the equivalent train with a stopped planet cage. Gear A' will thus be the driver.

If gear A' is the driver, $P_{AB}' = P_i R / \eta_t$ and the tooth mesh loss in the planetary train is

$$L_t = \frac{1}{\eta_t} P_i R (1 - \eta_t) \quad (32)$$

Efficiency of the train may be expressed by

$$e_t = \frac{P_i - L}{P_i} = \frac{\eta_t - (1 - \eta_t) R}{\eta_t} \quad (33)$$

where

$$R = \frac{\omega_K'}{\omega_K} = -\left(\frac{1}{m_p} - 1 \right) \quad (34)$$

Introducing the absolute value of R into Equation 33 gives

$$e_t = \frac{\eta_t - (1 - \eta_t) \left(\frac{1}{m_p} - 1 \right)}{\eta_t} \quad (35)$$

It is interesting to note that $e_t = 0$ when

$$\eta_t = 1 - \eta_t \left(\frac{1}{m_p} - 1 \right)$$

and this mechanism becomes self-locking.

Consider now a train of this type which has ratio $d_A d_J / d_B d_K > 1$. Such a mechanism will increase speed and reverse the direction of rotation when $1 < d_A d_J / d_B d_K < 2$. It will reduce speed and reverse the direction of rotation if $d_A d_J / d_B d_K > 2$. This latter case will be assumed for illustration. In this reduction drive, m_p is negative. Angular velocity of the planet cage is $\omega_G = \omega_K / m_p$, and the angular velocity of gear K with the planet cage stopped becomes

$$\omega_K' = \omega_K + \left(-\frac{\omega_K}{m_p} \right) = \omega_K \left(1 - \frac{1}{m_p} \right) \quad (36)$$

Because m_p in this case has a negative value, ω_K' is positive. The product of torque and velocity

at gear K' is positive, making this gear the driver in the equivalent train. Therefore, the tooth mesh loss in this train is given by Equation 13, and the efficiency of planetary trains of this type, in which the speed ratio is negative ($d_A d_J / d_B d_K > 1$), can be deteremined from Equation 14.

When $R\ (1 - \eta_t) = 1$, $e_t = 0$. The value of R for this train is given by Equation 11, where m_p is a negative value. The relationship between efficiency and speed ratio for this planetary train arrangement, *Fig.* 8*a*, is shown in *Fig.* 8*b*. This chart is based on the assumption that $\eta_t = 0.97$. When $m_p = +1$, the entire system revolves as a unit and $e_t = 1$, or 100 per cent. Actually, such a speed ratio is impossible to realize in practice because it requires that $d_A d_J / d_B d_K = 0$. Also, since the value of this diameter ratio cannot be negative, $m_p = +1$ is the theoretical maximum limit for positive speed ratios in this train.

When $\eta_t = R\ (1 - \eta_t)$, $e_t = 0$. For $\eta_t = 0.97$ this condition corresponds to $m_p = +0.03$. When the speed ratio is negative, $e_t = 0$ corresponds approximately to $m_p = -0.031$. Efficiency increases as the absolute value of speed ratio increases, approaching the value of η_t asymptotically as a higher limit. For $m_p = -25$, the efficiency of the train is 0.9688. This value may be considered as highly satisfactory for a planetary gear train of this type. However, this type of train can be designed only for relatively small speed ratios, having a maximum absolute value that is approximately of the same magnitude as may be obtained by two pairs of gears in a conventional gear train.

Modified Differential System: In another type of differential planetary gear train, *Fig.* 9, the sun gears are in the form of internal gears A and K. In this particular train, gear A is fixed and K is connected to the output shaft. Planet cage G is connected to input shaft D.

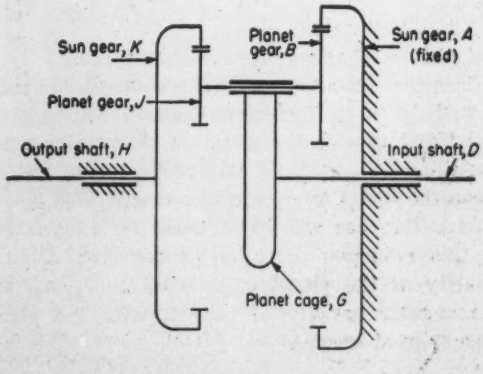


Fig. 9—Modified differential system in which the sun gears are internal gears

For this train, as in the arrangement shown in *Fig.* 7*a*, speed ratio is given by Equation 20. These two differential systems also have the same expressions for e_t and R. Here again, two principal cases must be considered: (1) $d_A d_J / d_B d_K < 1$ and (2) $d_A d_J / d_B d_K > 1$. In the first case, gear K' is the driver in the equivalent train with the planet cage stopped, and Equations 23, 24 and 25 must be used for efficiency calculations. For the second case, gear A' becomes the driver and Equations 28 and 29 are pertinent.

The only difference between the two train arrangements, *Figs.* 7*a* and 9, lies in the values for Δ_1, Δ_2, and η_t of the train. The losses in internal gears, if all other factors remain the same, are somewhat lower than for comparable external gear pairs. Therefore, the value of η_t may be considerably smaller for the internal gear arrangement, *Fig.* 9, than for the external gear system, *Fig.* 7*a*. Total efficiency for a planetary train of this type will thus be higher for a given speed ratio if internal gears are used.

Summary

Many different planetary gear arrangements can be obtained by varying the positions and size of the driving, driven, and fixed gear members. In each case, tooth mesh loss, efficiency, and power developed by the gears can be readily determined by the approach just discussed. Analysis of various planetary train types shows that efficiencies of all simple and compound systems may be expressed by one of four basic formulas: Equations 14, 23, 28 and 33.

Two basic conditions determine which one of these expressions must be used for a given case: (1) Whether the input shaft of a planetary train is connected to one of the sun gears or to the planet cage and (2) whether the position of the input shaft of the planetary train coincides or does not coincide with the position of the driving member of the equivalent train obtained by stopping the planetary cage.

This last condition depends upon the train design and, in some cases such as the differential systems, upon the diameter ratios of the gears constituting the given train. The magnitude of R in these expressions is a function of the type of planetary train and gear size relationships. This value can be positive or negative. In all cases, the absolute value of R must be used for calculation of tooth mesh losses and efficiency. In the expressions developed here, losses due to oil churning, as well as those introduced by the support members, have not been considered.

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Designing Wire Parts

Techniques for practical production design of wire components and assemblies

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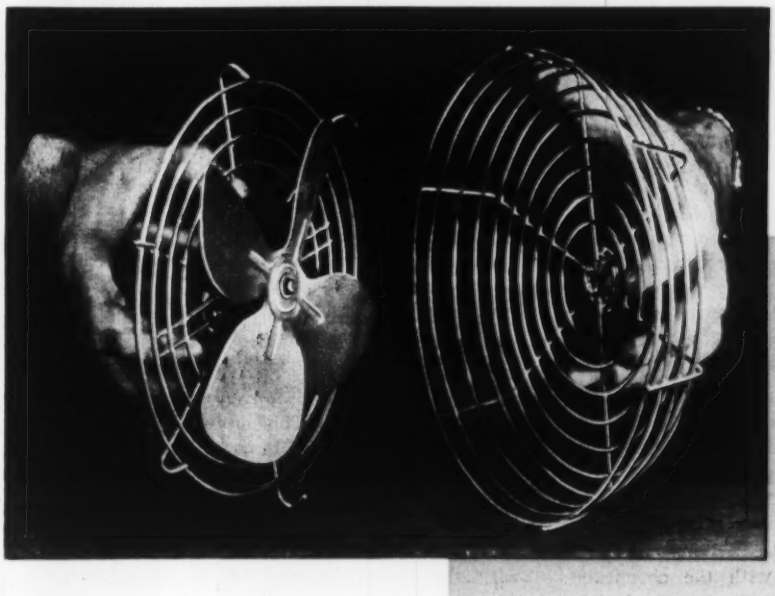
USE OF WIRE in the manufacture of metal products is becoming increasingly popular. A piece of wire, formed in a particular shape, or combined with one or more strip-metal parts by a welding or assembling operation, can often accomplish the same result as a more expensive metal construction.

Although steel wire in coils represents the bulk of wire used, *Table* 1, a wire products manufacturer also uses nonferrous wires. A coil of wire, according to the size, *Table* 2, may contain from 50 to 250 pounds, and from 100 to 8000 feet.

Wire Forming Methods: By far the least costly of all wire forms are those which can be made in a single operation, at high speed, on automatic forming equipment known as four-slide machines. A feeding mechanism pulls the wire through a series of straightening rollers, and the wire is then cut off automatically to the proper length for the piece to be formed. At the same instant it is wrapped around a central core or center die by the motions of four sliding blocks equipped with dies.

By varying the shape of the central core and



Defroster Fan Guard: **Lightweight welded wire assembly snaps together for assembly. Guards also nest together in shipping for low freight costs.**

the dies attached to the sliding blocks, various shapes can be achieved. Such items as wire handles, coat hanger hooks, loops, rings, etc. are made in this manner. All of these generally lie in a flat plane since they have been formed around a fixed center die by the four sliding dies.

In addition, some of the four-slide machines have an up-and-down motion called a vertical former, which bends certain parts in another plane. There are limits to the number of bends which can be added in a vertical plane. However, by the use of ingenious tooling, much can be accomplished by using four horizontal motions and one vertical motion.

Table 1—Types of Wire

Round Basic Steel Wire: This description is attached to most of the round steel wire which is used in general wire products manufacturing. Sometimes this wire is called "nail wire", sometimes "bright market wire" and sometimes "plain wire".

Extra-Clean, Extra-Bright Wire: Ordinary bright basic wire, specially drawn for a quality finish. The surface of this wire is supposed to be free from scratches and compounds, is furnished with an extra-clean and a special bright finish. This quality of wire is needed for production of wire products to be plated; it is also needed for reliable and fast production of electric welded assemblies. It is produced by mills with special drawing and lubrication in order to obtain the smoothest and brightest possible surface.

Annealed-in-Process Wire: This is dry-drawn and annealed at an intermediate stage between rod size and finished size, in order to produce a softer wire of fairly uniform temper. It is important to use this grade where bright wire would be too stiff or too hard for a given forming operation.

Galvanized Steel Wire: A regular commercial mill product, this wire represents a material that can be counted on for rust protection for a reasonable period of time. Very large quantities of wire products and assemblies are made of this grade of galvanized wire. Galvanized wire is zinc coated and made by passing bright wire through molten zinc. This wire is made in various tempers depending on the application.

Bethanized Wire: A special grade of galvanized or zinc-plated wire. It is coated by electroplating from zinc concentrates. It is available in brighter finishes than ordinary galvanized wire. Has added quality which provides a better nonrusting and noncorrosive protection. This material is made in several grades in accordance with the quality of finish needed. Some of the more expensive grades of Bethanized wire are used where superior nonrusting and noncorrosive characteristics are important.

Coppered Wire: A regular mill product suitable for making many wire products where a bright, attractive finish is desirable, but where cost consideration will not permit using a special plated finish. Coppered wire is produced by wet-drawing wire with a copper sulphate or copper-tin sulphate solution. The color of this wire varies in accordance with the chemicals used. The drawing operation imparts a luster to the wire that is useful in improved appearance. It has only limited rust and corrosion resistance.

Tinned Wire: Also a material used for products that require a special bright, attractive finish, where costs do not permit a special plating after making. Tinned wire is bright wire coated with tin by passing through a bath of molten tin.

Cadmium-Plated Wire: Steel wire with cadmium-plated finish is usually available. This coating provides an excellent rustproof coating.

Spring Steel Wire: This is wire of the proper chemistry to impart added tensile strength and added stiffness over basic low-carbon wire. In general, the types commonly used in wire forms are:

MB Spring Wire Hard Drawn: A medium carbon (0.45/0.70 carbon) basic steel wire drawn without annealing and used for ordinary springs and for wire forms where stiffness greater than imparted by low-carbon wire is required.

Upholstery or Bed Spring Wire: A slightly lower-priced spring wire of characteristics similar to MB wire but not held as closely to chemical specifications.

Annealed MB Wire: MB wire spheroidized annealed at finished size and intended for production of parts to be heat-treated subsequent to manufacture.

Music Wire: Spring wire of higher chemistry and made to closer tensile ranges and higher finish specifications than MB wire.

Stainless Steel: Practically all types of stainless steel wire are available in coiled wire. Selection of stainless steel type is optional to customers in accordance with the rust and corrosion resistance required.

Monel Metal Wire: Various grades of Monel metal are also available in all gages of coiled steel wire.

Nonferrous Metals: Coiled wire is available in all nonferrous metals. Wire formings and assemblies are made in quantities from bare copper, bronze, brass, nickel silver, and aluminum.

Copper-Clad Wire: This material is used extensively in coiled wire. It is applicable to products which require an excellent nonrusting and noncorrosive finish, and where improved electrical conductivity is needed. This wire is mainly steel. It has a copper armor which is drawn with the steel wire and which approximates 10 per cent of the diameter.

Wire should preferably be round for fast production, although half-oval or flattened wire may also be formed automatically. Some machines are equipped with separate press attachments which will form swaged areas, flat or extruded ears, etc.

Typical limitations for automatic wire forming are 1/16 to 5/16-inch diam wire and approximately 21 inches in length for a single automatic operation.

HAND AND SEMIAUTOMATIC FORMING: Forms which require a length of material longer than can be accommodated in automatic machines can be fabricated by several methods. Special bending devices are utilized, some manually operated, others mechanically driven. Often power presses are utilized for severe bends. Wire must be straightened and cut to the proper length. Then, through a series of hand-fed operations, it is formed into the desired shape. When special treatment of the wire ends is called for, it is possible to furnish milled ends, threaded ends, pointed ends, sheared cut ends, etc., by use of special machines, milling heads and other special tools.

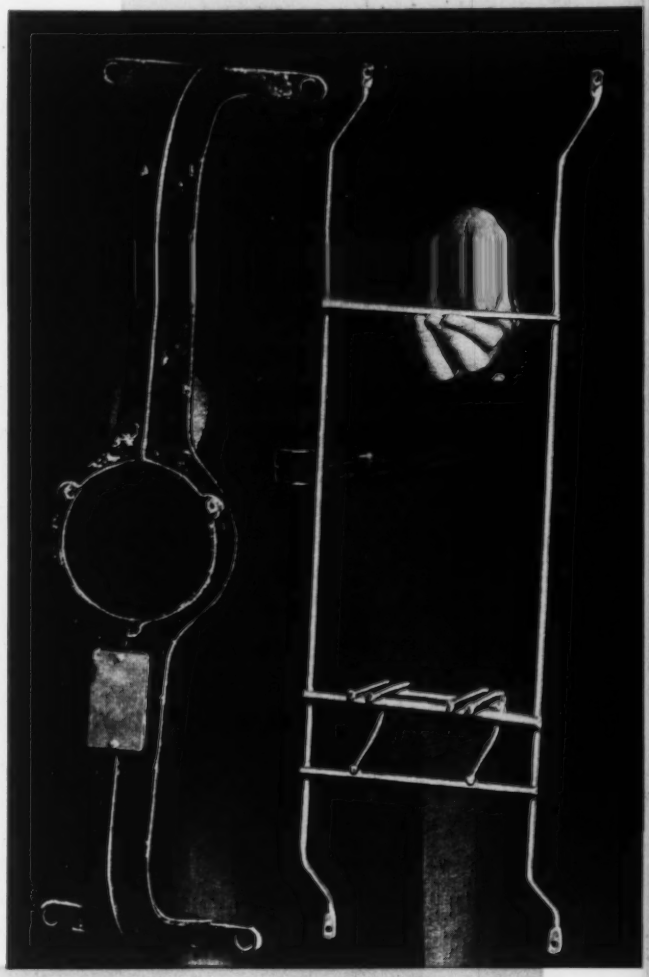
Designing Wire Shapes: As mentioned previously, the preferable method of designing wire shapes is to have all bends in the same plane, since the part can easily be made on automatic machines. If necessary, bends in a second plane can be handled, either by use of the vertical slide in automatic machines or by a separate operation.

EYES AND EARS: Eyes are sometimes necessary on one or both ends of a part. The easiest eye to make is the "pear-shape" or "tear-drop" shape, *Fig.* 1. In this type the centerline of the wire does

Table 2—Comparison of Wire Gages

Gage No.	Wash & Moen (W & M) (in.)	Brown & Sharpe (B & S) (in.)	Birm. or Stubs (in.)	Sheet Steel (U.S. Std.) (in.)
0	0.3065	0.3249	0.340	0.3125
1	0.2830	0.2893	0.300	0.28125
2	0.2625	0.2576	0.284	0.265625
3	0.2437	0.2294	0.259	0.25
4	0.2253	0.2043	0.238	0.234375
5	0.2070	0.1819	0.220	0.21875
6	0.1920	0.1620	0.203	0.203125
7	0.1770	0.1443	0.180	0.1875
8	0.1620	0.1285	0.165	0.171875
9	0.1483	0.1144	0.148	0.15625
10	0.1350	0.1019	0.134	0.140625
11	0.1205	0.09074	0.120	0.125
12	0.1055	0.08081	0.109	0.109375
13	0.0915	0.07196	0.095	0.09375
14	0.0800	0.06408	0.083	0.078125
15	0.0720	0.05707	0.072	0.0703125
16	0.0625	0.05082	0.065	0.0625
17	0.0540	0.04526	0.058	0.05625
18	0.0475	0.04030	0.049	0.05
19	0.0410	0.03589	0.042	0.04375
20	0.0348	0.03196	0.035	0.0375
21	0.03175	0.02846	0.032	0.034375

***Motor Mount:* Wire motor mount accommodates several motor sizes, in contrast to original aluminum casting. Additionally, transmitted noise is less, and machining operations have been eliminated.**



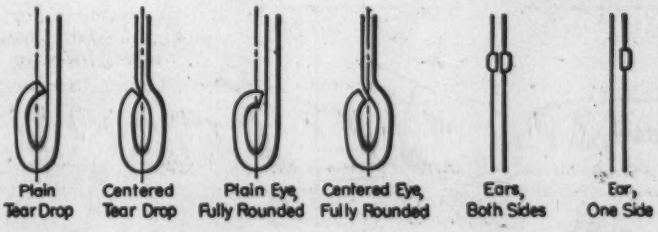


Fig. 1—Eyes and ears formed on wires by automatic machines or special operations

not coincide with the center of the eye.

Sometimes it is very essential that the eye be centered; that is, the centerline of the wire must coincide with the center of the eye. This can be accomplished with special operations.

Finally, it is possible to make eyes on wire formings that are fully closed or entirely round. As compared to the tear-drop formation, this fully round or completely formed eye is often more expensive to accomplish.

Ears, *Fig.* 1, are made with press tools, sometimes on one side, and sometimes on both.

RINGS: When made on four-slide automatic machines, rings will have ends that do not butt perfectly, *Fig.* 2. Such rings can be from ½ to 2 inches ID (½-in. ID for 1/16-in. wire; 2 in. ID for 5/16-in.).

Rings made on a ring coiler are generally from ⅝ to 3 inches ID for wire diameters mentioned previously. Rings so produced have a characteristic spiral offset, *Fig.* 2. This is particularly true of smaller sizes. If the ID of the ring is less than 10 times the wire diameter, the offset will be about one wire thickness. This spiral offset can be corrected by a flattening operation.

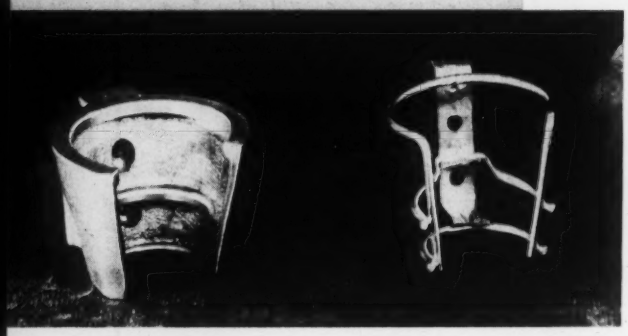
END TREATMENTS: Most end treatments shown in *Fig.* 3 can be handled on automatic machines. Exceptions are the two chamfers, which must be done in a separate milling operation. The long bevel shear cut is an end treatment designed for staples and similar fasteners with sharp ends.

THREADED ENDS: Wire ends can be threaded either by rolling or cutting, *Fig.* 4.

Since the metal is extruded to form rolled threads, the thread diameter is larger than the basic wire OD. For example, a ¼-20 thread would be rolled from a 0.214-inch wire. If the thread is cut, the wire OD would be the same as the thread OD; i.e., a ¼-20 thread would be cut from 0.250-inch stock. Another difference between the two methods is that ends of rolled threads are not chamfered, whereas cut thread ends should be for easy starting of the nut.

Rolled threads are less expensive, since they are faster to make and do not require special cutting fixtures. Additionally, a smaller wire size can be used for the same size thread. However, thread length is limited to about 1¾ in. on 5/16-in. wire

Bulb Holder: **Die-cast electric bulb holder originally used on conveyor line required several machining operations and left an objectionable black ring around the bulbs. Welded stainless-steel wire assembly is supplied at about one-half the cost.**



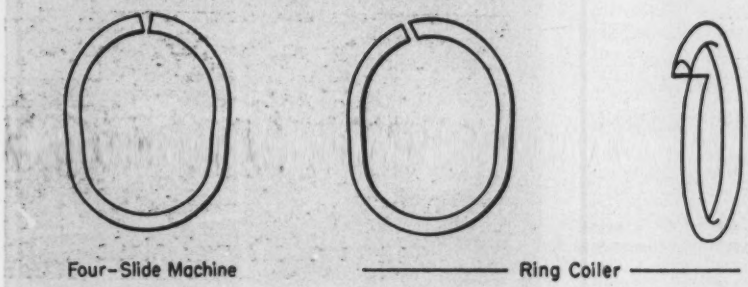


Fig. 2—Ring formings as made on automatic four-slide machines and on ring coilers

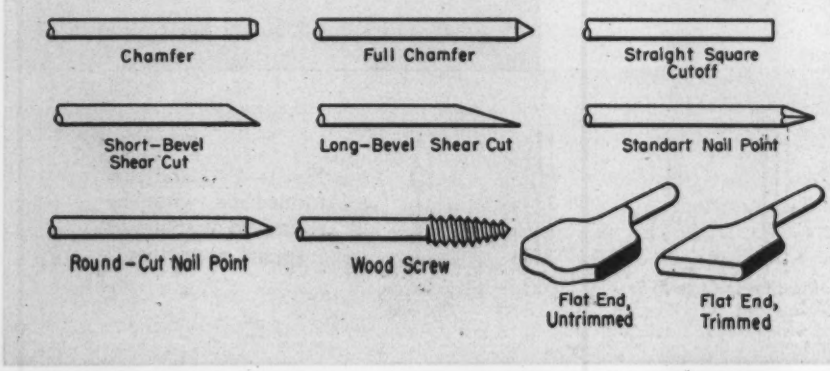


Fig. 3—End treatments for wire

and 2 in. on smaller sizes. Cut thread length is unlimited.

Welding Wire Assemblies: Regarding methods of attaching wires together, or attaching wire to strip parts, the most efficient operation is electric spot welding, *Fig.* 5. Carbon-steel wire and certain types of stainless-steel wire are very well adapted to this type of welding. Small wires may be satisfactorily welded to larger diameter wires, and wires of equal diameter may also be joined. It is often necessary to weld two ends of wire together in a butt welding operation to complete such parts as closed rings, frames, etc. In this operation there is a slight surplus of metal which projects beyond the regular surface of the wire as a result of the weld. This surplus or "flash" can either be removed or swaged smooth, in an extra operation, if it is objectionable.

A straight piece of wire may be T-welded into the side of another piece of round wire successfully by the development of special holding fixtures. This is a common operation on such parts as refrigerator shelving and wire grilles.

In designing wire products which are to be welded, the welds should preferably occur where two wires cross each other at right angles, or nearly so. This is generally known as cross-wire welding. It is not good practice to weld two wires lying parallel to one another.

In joining strip material to wire, a much better concentration of the welding current is obtained by forming a small welding projection in either the wire or in the strip steel part, or in both. If wire is laid flat on the surface of a strip part, the current has a tendency to become dispersed over a larger area, thus making an uncertain weld and causing slower production speeds.

There are some limitations regarding the finishes of wire that can be used in welded assemblies. Such wires as galvanized, copper coated, tinned nickel plated and other specially coated wires can be welded successfully. However, there is the slight objection in that the coating will be burned during the welding. This leaves a slight discoloration on the wire at the point of weld.

Plating and Finishing: Wire products may be finished by plating, painting or lacquering. Among the plated finishes, the most popular are nickel, chromium, cadmium and zinc.

A great deal of progress has been made in the development of a bright zinc plate. Brilliance is achieved by the use of special chromate dips. These chromates have a tendency to polish the zinc, bringing out a high luster. They also seal

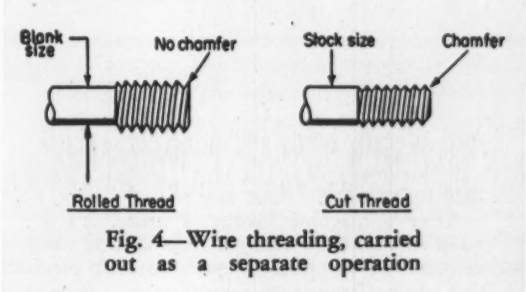
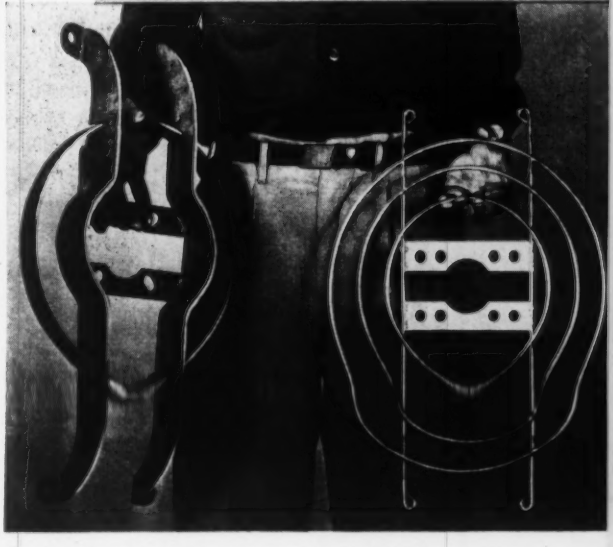


Fig. 4—Wire threading, carried out as a separate operation

Motor Mount: **Weight reduction of 75 per cent is provided by welded-wire assembly as compared with previous sheet-steel assembly. Quieter operation with equal performance record are features.**



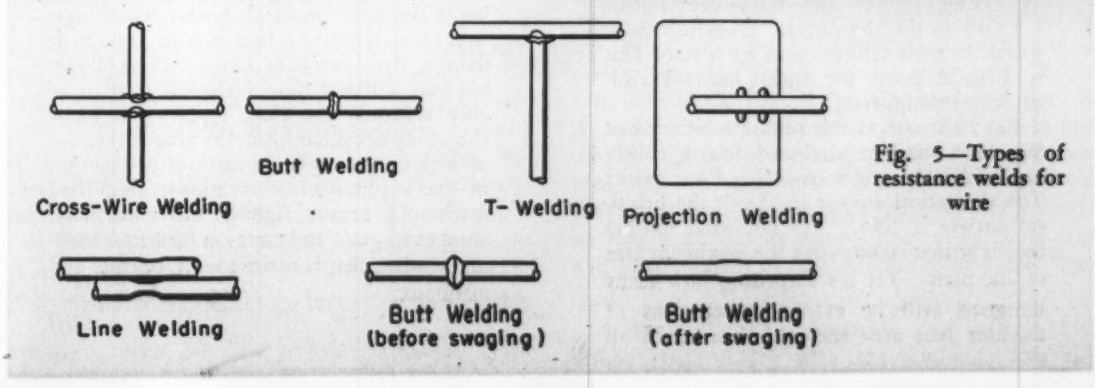
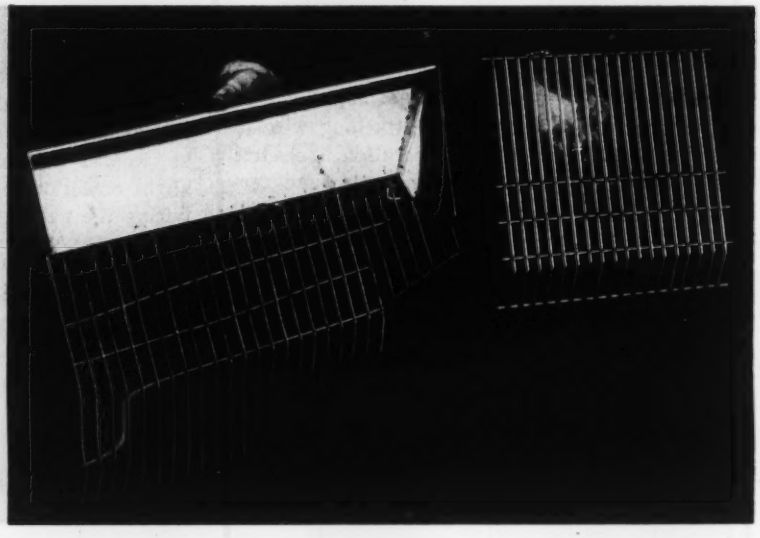


Fig. 5—Types of resistance welds for wire

Ice-Cube Deflector: Lack of drainage in the sheet-aluminum pocket was a problem in original deflector for an ice-cube machine. Stainless-steel welded-wire rack eliminates the problem.



the pores of the zinc in such a way that improved corrosion resistance is achieved. The chromate film is rather thin, however, and relatively soft, making it vulnerable to abrasion. For this reason it is advisable, when allowable from a cost standpoint, to add a baked lacquer to preserve the chromate film. This operation provides an attractive and lasting finish even under severe conditions of moisture.

Cadmium plating is used to provide a good corrosion-resistant surface. However, it is not quite as brilliant in appearance as zinc-chromate plating.

Wire products may be plated with bright nickel, and this is often followed by a chromium flash. The wire will then have a brilliant surface without the necessary buffing which accompanies the plating of castings or forgings. In such welded-wire assemblies as refrigerator shelves where chromium plating is used, a further improvement is accomplished by adding a baked lacquer coating to protect the finish.

For small parts, the barrel plating method is used. This process is limited to products which are simple in formation; otherwise they will become deformed by the tumbling operation. If tangling will occur, the parts must be tank plated, using racks which hold the pieces individually.

In addition to plating, wire products may be painted by dip or spray methods, followed by either an air dry or a bake operation.

Recent developments have added several finishes which have pleasing decorative qualities. These are brass, copper and black oxidized zinc. The brass and copper platings must be protected by a coating of clear lacquer to prevent tarnishing. The black oxidized zinc also should be protected with a lacquer coating to prevent abrasion.

A rubberlike coating known as plastisol is also applied to wire products. This is a dip and bake process which produces a soft, highly protective coating securely bonded to the wire. It is available in a variety of colors.

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industrial design Ideas

shrinking floor space

ADVERTISING and sales departments love to use the phrase "takes less floor space" in their selling—and rightly so. This is a good point for them *and* for cost-conscious designers.

But let's analyze this phrase a bit further. Would a machine designed like a child's top be the ultimate in reducing floor space? The theoretical answer is "Yes"; the practical answer is "No." It's not what touches the floor that counts—it's the maximum area of the plan. Yet it's surprising how many designers will be extremely conscious of machine base area and will then attach all sorts of ears, horns and projections which take up valuable "floor space."

After a machine layout is made, it's a good idea to draw straight lines around the extremes of the plan to get a realistic picture of the floor-space requirements. First, try to reduce this area to a minimum, then see if the most practical, lowest cost design won't resolve itself best within this basic shape. Your new base design may be larger, but you will not have increased (but probably reduced) the floor space. I've done this many times, and benefits always result—savings on patterns and castings (or savings in every phase of fabrication), simplified machining, greater rigidity, easier assembly, cheaper to paint and crate—a far better looking product that is easier to sell, operate and maintain.

—*Cliff*

Cam Development by Evolute Analysis

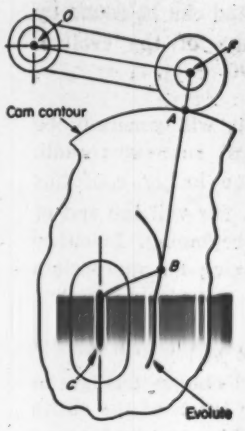


Fig. 1 — Portion of cam and corresponding portion of evolute, showing equivalent four-link mechanism with *CB*, *BF* and *FO* as the movable links

Fig. 2—Evolute having a slope discontinuity at point *A*, which produces circular arc from *B* to *C* on cam contour

By Theodore Weber, Jr.
New City, New York

A USEFUL aid in developing and analyzing a cam contour is the locus of its center of curvature, or evolute. *Fig.* 1 shows a portion of a cam and a corresponding portion of its evolute. A line drawn through the follower roller center tangent to the evolute will pass through the contact point *A* and the point of tangency *B* will be the center of curvature of the cam surface at *A*. The cam and follower may then be replaced by an equivalent four-link mechanism with *CB*, *BF* and *FO* the movable links. The acceleration of the follower may then be determined graphically by standard methods.* The evolute thus makes possible a simple graphical analysis of the dynamics of a cam.

Another useful property of the evolute is that a first-derivative discontinuity therein results in only a second-derivative discontinuity in the cam contour which is its involute. Thus even if the evolute should have a slope discontinuity at any point such as *A*, *Fig.* 2, this would merely result in a circular arc from *B* to *C* on the cam contour, which would be tangent to its adjacent sections.

It follows that an evolute polygon made up of a series of short straight lines defines a cam of as many short, mutually tangent circular arcs, *Fig.* 3. Such an evolute polygon then becomes a useful means of defining the cam contour and is used in actual practice rather than the ideal curvilinear evolute.

The designer simply lays out his contour with the aid of circular arcs instead of a french curve. If he assures tangency of adjacent arcs by keeping their centers colinear with their transitional points of tangency the evolute polygon automatically results. It is then necessary only to establish the coordinates of each vertex and to assign to each a radius of curvature. The sides of the polygon, extended when necessary, give the points of tangency between adjacent arcs.

It is evident that by increasing the number and shortening the lengths of the circular arc segments a given cam contour may be simulated to any desired degree of exactness. However, it is seldom essential that a specific contour be faithfully simulated. Except for high speeds it usually is only necessary to connect specified points and dwells with a contour having good dynamic characteristics. In such cases the designer should avoid the traditional special cam curves which could be simulated only by a large number of short arcs and avail himself of the simplicity of a few long ones.

If, for instance, a moderate rise between two dwells is generated with the minimum two cir-

*George L. Guillet and Austin H. Church, *Kinematics of Machines*, John Wiley & Sons Inc., New York, 1950, Section 6.24.

cular arcs, neither the peak accelerations nor the acceleration discontinuities are substantially greater than those obtainable by the traditional parabolic, sinusoidal and other special curves.

When cam surfaces are developed with reasonably few circular arcs, the compactness of the data becomes obvious as compared with that required to generate the surface point by point to an equal degree of smoothness. Moreover, such cams can be readily fabricated, an entire arc at a time, on a milling machine with a rotary table. This is particularly important in the development stage of new devices. The checking of such cams can also be readily accomplished by indicating an entire arc at a time for concentricity about its specified center and measuring its radius.

A further useful property of the cam evolute is its independence of follower roller diameter. The locus of the follower roller center has the same evolute as the cam contour regardless of roller diameter. It is therefore perfectly permissible to dimension the cam surface directly instead of the follower center locus and to let the fabricator use any convenient diameter cutter to generate the cam. Moreover, a change in the size of the follower roller is easily accommodated by a corresponding simple addition or subtraction on each radius of curvature.

Dimensioning Circular Arc Cams: When a cam has been laid out in circular arcs and it is necessary to convert this layout to numerical dimensions, the coordinates of the arc centers may be found by scaling the layout. One of the radii may also be scaled. All remaining radii are successively determined as seen in *Fig.* 4 and can be found by computing the successive sides of the evolute. Then, $r_2 = AB - r_1$, $r_3 = BC - r_2$, $r_4 = r_3 - CD$, etc.

Due to scale inaccuracies it will generally be found, after computing several successive radii, that the computed contour no longer conforms exactly to the layout contour, nor will the end of the contour exactly meet the beginning. In either case the remedy lies in changing an appropriate arc center.

In order to avoid solving an oblique triangle in such cases, advantage may be taken of the shifts in location being small. Therefore, any center may be moved perpendicularly to a radius without changing that radius.

Assume for instance in *Fig.* 4 that the computed contour at P is inside the layout contour by an amount e. An enlargement of the region about point E is drawn, *Fig.* 5. Perpendiculars are constructed to DE and EF and a parallel to the latter a distance e away. A new center E' may then be found and corresponding coordinate corrections ΔX and ΔY. Distance DE will not have been changed because the center has been moved perpendicularly to it and the contour at P will have been augmented by the amount e.

The error of closure can be corrected in the same way, e being the difference between the initially assigned radius and its value when it is in turn redetermined as a result of successive computation of radii.

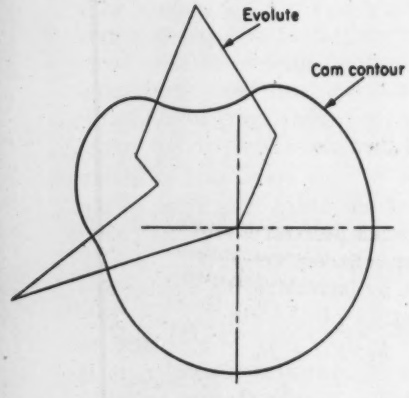
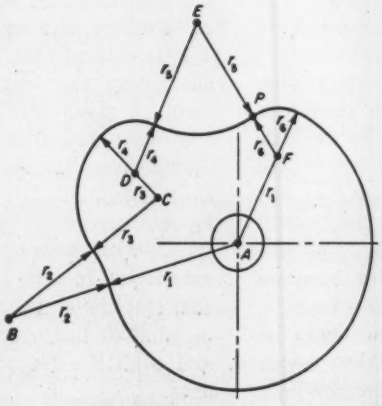


Fig. 3—Above—Evolute polygon with its corresponding cam contour

Fig. 4—Below — Complete cam contour with arc centers and radii. Compare with *Fig.* 3



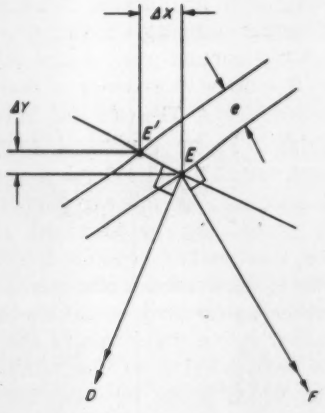


Fig. 5 — Above — Enlargement of region about point *E*, *Fig.* 4, illustrating method of correcting for variations between computed contour and layout contour

Design Analysis of

JOURNAL BEARINGS

A quick, simple but rigorous method for determining minimum oil film thickness in a journal bearing and recommendations for practical journal bearing design.

By Dudley D. Fuller

Professor of Mechanical Engineering
Columbia University
New York

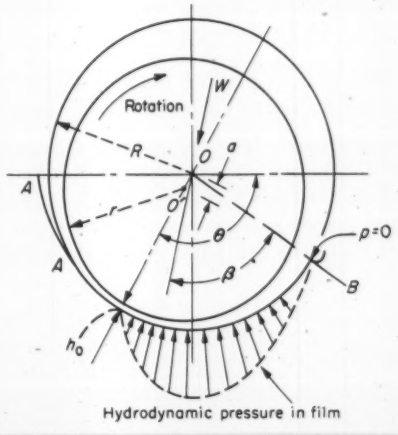
JOURNAL bearings are the simplest, most familiar and perhaps most useful of all bearings. Design of journal bearings is not difficult, if the fundamentals of their operation are understood. Experience has shown, however, that incorrect designs are continually giving trouble as new machines are placed in operation or old machines are run at higher speeds.

Although a great deal is known about journal bearing operation, few attempts to digest and systematize the great mass of information on this subject have been made. This article presents a design technique based on analysis of these combined efforts of the experts in the fields of bearing design and lubrication.

Based on rigorous hydrodynamic theory, the design technique is closely integrated with the various vital aspects of bearing design. These include temperature rise, heat balance, elastic and thermal distortion, film thickness, lubricant flow, grooving, clearance, and mechanical design of the bearing and its housing.

This article is based upon a chapter of *Theory and Practice of Lubrication for Engineers* to be published early this year by John Wiley & Sons, Inc., New York.

Fig. 1—Hydrodynamic pressure in a journal bearing supports the shaft, or journal on a thin oil film. Metal-to-metal contact and wear are, therefore, greatly reduced if not eliminated. Centers of shaft and bearing do not usually coincide. Oil film thickness, clearance, speed and other factors have effects depending on the amount of separation existing



Design Analysis

If the lubricant film in a bearing becomes too thin, metal-to-metal contact will be initiated and under many circumstances the bearing will destroy itself. Primary concern in design is, therefore, with the minimum film thickness between the shaft and the bearing. Second, the engineer is concerned with the friction loss in the bearing. This enables him to estimate the friction horsepower that will be expended and determine the heat that must be removed from the bearing in order to maintain its temperature at a reasonable steady-state level. Third, the amount of oil required by the bearing must be evaluated and provision made to introduce this lubricant at the proper place in the bearing. Fourth, the physical design of the bearing, its supports, and the housing in which it is placed must be considered so as to reduce elastic and thermal distortions to a minimum and provide the least interference with the development and main-

tenance of the designed oil film throughout the range of expected operation.

When starting, with metallic contact between the shaft and the bearing at a point under the load, *Fig.* 1, the shaft will start to run up the right side of the bearing toward point *B*. After rising a few degrees of arc it will enter a region where oil comes between the bearing and the journal. Slip will begin. Then as the journal comes up to speed it will revolve faster and faster and build up a wedge-shaped film, which will then place the journal in the position shown.

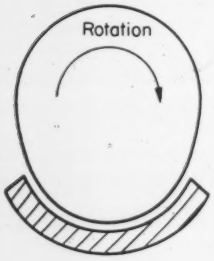


Fig. 2 — In partial bearings, the leading edge of the supporting oil film is limited by the extent of the bearing itself

A polar diagram of film pressures shows the extent of the arc of actual load-carrying lubricant film. The leading edge of the film may be established by an oil distribution groove, such as at *B*, by a relief such as *A-A*, or by the actual limit of the bearing itself, *Fig.* 2.

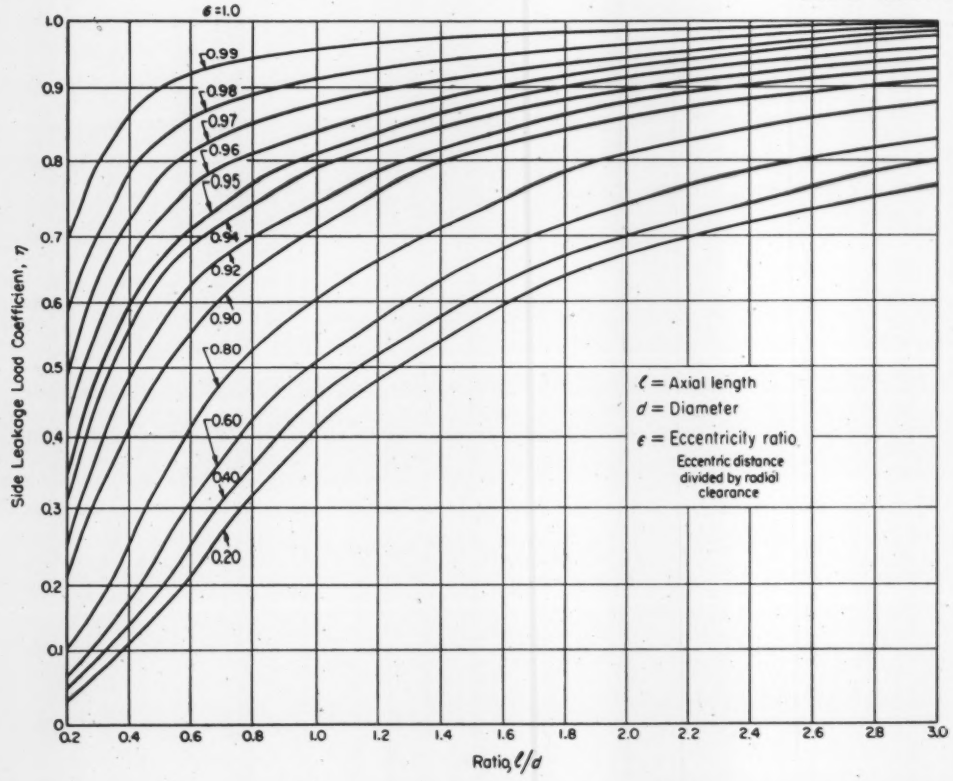
The trailing edge of the load-carrying film is considered as terminating at the point of closest approach between the shaft and bearing. Beyond this point the clearance space is no longer converging, but begins to diverge. The film thickness

Side Leakage Factors for Journal Bearings

	Values of side leakage factor, η, for eccentricity ratios, ε, of . . .											
l/d	0.2	0.4	0.6	0.8	0.9	0.92	0.94	0.95	0.96	0.97	0.98	0.99
∞	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2.0	—	—	—	—	0.867	0.88	0.905	0.919	0.937	0.952	0.97	0.99
1.5	—	—	—	—	0.823	0.84	0.865	0.882	0.906	0.93	0.95	0.975
1.0	0.42	0.455	0.51	0.605	0.72	0.745	0.79	0.82	0.843	0.878	0.91	0.958
0.8	0.33	0.36	0.43	0.53	0.66	0.70	0.75	0.775	0.815	0.85	0.89	0.94
0.6	0.22	0.255	0.3	0.42	0.56	0.63	0.695	0.72	0.772	0.82	0.865	0.925
0.5	0.17	0.2	0.235	0.33	0.50	0.56	0.635	0.67	0.732	0.783	0.84	0.908
0.4	0.12	0.14	0.17	0.25	0.40	0.47	0.55	0.59	0.661	0.725	0.795	0.875
0.3	0.07	0.09	0.105	0.17	0.30	0.355	0.435	0.47	0.551	0.625	0.705	0.81
0.2	0.035	0.045	0.058	0.1	0.205	0.235	0.305	0.34	0.406	0.748	0.565	0.7
0.1	—	—	—	—	0.105	0.115	0.155	0.18	0.220	0.28	0.36	0.53

Fig. 3—Relationship of ϵ, η and l/d ratio of a bearing are necessary to the solution of Equations 1 and 2. Data based upon work of Kingsbury[1], Needs[2] and Dennison[3]

1. References are tabulated at end of article.



at the point of closest approach is designated as h_o. A negative pressure will be established in the crown of the bearing and will contribute very little to the load-carrying function of the bearing since the positive oil film pressures are generally many orders of magnitude larger than these negative pressures. Point O represents the center of the bearing and O' the center of the shaft. The radius of the shaft is r, and the radius of the bearing R.

Distance between O and O' is indicated by a and is the eccentric distance. The ratio of a for the actual operating conditions to the radial clearance in the bearing is called the eccentricity ratio, ε. For light loads and high operating speeds the center of the shaft and the bearing coincide, and a approaches zero. The eccentricity ratio also approaches zero. For heavy loads or extremes of operation, such as low speed or very low viscosity, the journal becomes more eccentric in the bearing and the distance a increases. The limit is where the journal just begins to make metallic contact with the bearing, or the distance a equals the radial clearance. The eccentricity ratio is then 1.

From the geometry of the shaft and bearing it can be seen that

$$h_o = mr\ (1 - \varepsilon) \qquad (1)$$

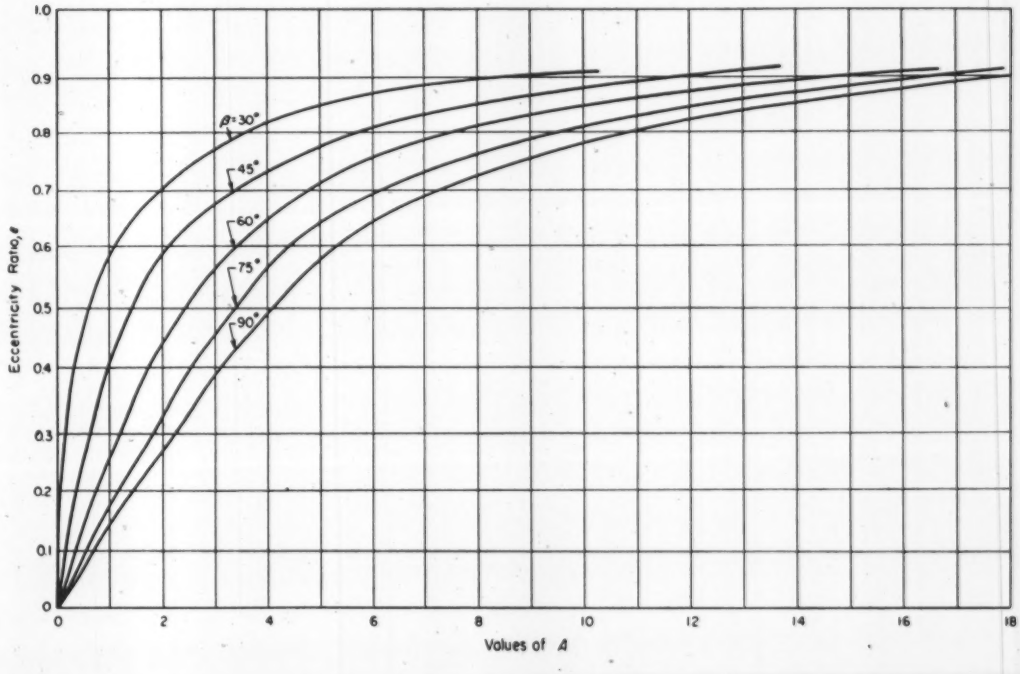
The question of what constitutes the lowest permissible limit of film thicknesses is a very pertinent one. It is a matter of practical considerations relating to the mechanical and thermal aspects of the bearing elements rather than any analysis of hydrodynamic action. The smallest acceptable film thickness depends upon the degree of finish of the sliding surfaces, on the elastic rigidity of the journal and bearing structures, on the maximum expected thermal distortion of the clearance space due to thermal gradients, and finally on the expected size of any contaminating particles that may find their way into the lubricant stream and attempt to pass through the clearance space and through the minimum film thickness.

In practice, h_o = 0.00075-in. is common in electric motors and generators of medium speed (500-1500 rpm) with the usual construction of steel shafts in babbitted bearings. With large steel

Values of Design Factor A

ε	Values of A for angles β (degrees) of ... 30	45	60	75	90
0.2	0.1	0.3	0.7	1.2	1.6
0.3	0.2	0.62	1.2	1.8	2.4
0.4	0.4	1.00	1.75	2.6	3.2
0.5	0.66	1.48	2.45	3.45	4.0
0.6	1.15	2.12	3.38	4.48	5.18
0.7	1.90	3.35	4.80	6.30	7.15
0.8	3.50	5.75	7.75	9.55	10.50
0.9	8.60	12.20	15.20	16.90	19.00

Fig. 4—Values of A corresponding to various values of β and ε are used in a convenient method for determining minimum oil thickness in hydrodynamically lubricated bearings. Data based upon work of Karelitz[4]



shafts running at higher speed (1500-3600 rpm) in babbitted bearings (turbogenerators, fans, etc.), h_o = 0.003 to 0.005-in. For small, rigid automotive and aviation engine bearings, with very finely finished surfaces, h_o = 0.0001 to 0.0002-in. With film thicknesses of this low magnitude, it is important that the filters in the system be able to remove all particles with diameters larger than the expected minimum film thickness or serious wear of the bearing and shaft may take place.

With rigid bearing and shaft construction and good commercially smooth materials, it seems that the lowest practical limit for fluid film lubrication is where h_o equals approximately 0.00005-in. With larger, commercial-type bearings the probable lower limit of fluid films would be about 0.0001-in. And with considerations of possible particles of contaminants in the lubricant and elastic and thermal distortion of the geometry of the shaft and bearing, the lower limit of fluid films may well be established at a higher value.

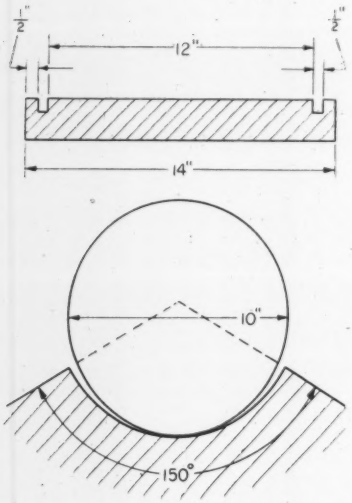
To determine film thickness conveniently from Equation 1, it is necessary to determine ε under working conditions. This is done using the expression

$$A = \frac{132}{\eta} (1000\, m)^2 \frac{p_{avg}}{zN} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

and *Figs.* 3 and 4. The method is one of trial and error but the results are sharply convergent. Experience has shown it to be not only simple and fast but extremely accurate.

EXAMPLE 1: To illustrate the use of the method, some sample problems will be solved. First, ex-

Fig. 5—Dimensions of the partial bearing considered in *Example* 2



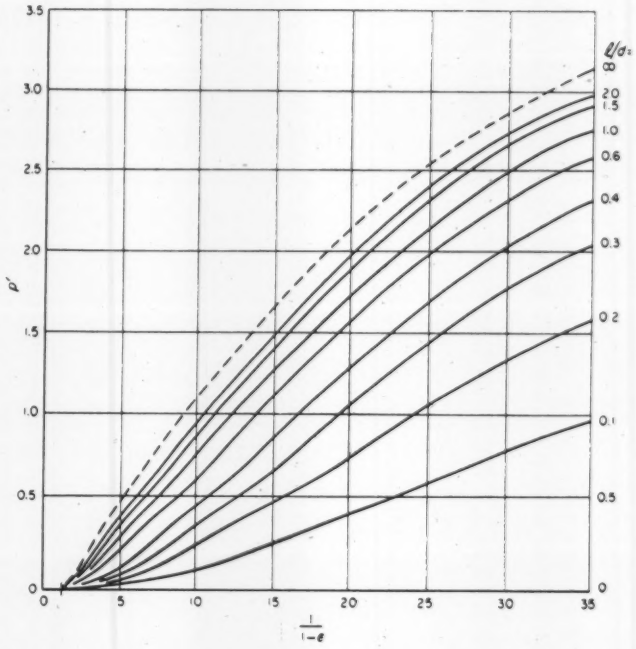


Fig. 6 — When eccentricity ratio, ϵ, is high, the previously used charts cannot be employed. Values of $1/(1-\epsilon)$ are plotted against l/d here to extend the use of the method to bearings with high eccentricity ratios

Values of Design Factor p'

l/d	Values of p' for ε = 0.800	0.900	0.933	0.950	0.960	0.967	0.971	0.975
	$1/(1-\varepsilon)$ = 5	10	15	20	25	30	35	40
0.1	0.023	0.114	0.230	0.40	0.56	0.73	0.91	1.04
0.2	0.053	0.228	0.455	0.76	1.03	1.29	1.54	1.72
0.3	0.086	0.338	0.66	1.05	1.40	1.71	1.99	2.21
0.4	0.121	0.450	0.85	1.30	1.68	2.02	2.28	2.52
0.5	0.161	0.551	1.00	1.47	1.86	2.21	2.46	2.71
0.6	0.195	0.625	1.10	1.56	1.96	2.29	2.56	2.80
0.8	0.251	0.712	1.20	1.67	2.07	2.40	2.65	2.89
1.0	0.293	0.778	1.27	1.76	2.14	2.48	2.73	2.96
1.2	0.320	0.825	1.33	1.82	2.22	2.54	2.80	3.03
1.5	0.349	0.892	1.40	1.90	2.30	2.63	2.88	3.11
2.0	0.380	0.940	1.47	1.98	2.38	2.70	2.95	3.19
∞	0.484	1.084	1.638	2.154	2.540	2.844	3.096	3.32

pected eccentricity and minimum film thickness for a journal bearing will be calculated, with data taken from Barber and Davenport.[5] This is for a complete journal bearing (360 degrees): $N = 1600$ rpm; $p = 271$ lb/in.^{2}; average viscosity of the oil film = 54 centipoises; bearing length = 2.375 in.; shaft diameter = 2.504 in.; l/d ratio = 0.95; diametral clearance = 0.0094 in.

First assume a value for the eccentricity ratio, ε. Suppose the first estimate is 0.7. Then from *Fig.* 3, with $l/d = 0.95$, and $\varepsilon = 0.7$, the value of η is approximately 0.54 and $m = 0.0094/2.504 = 0.00375$.

Next from Equation 2 calculate the value of A.

$$A = \frac{132}{\eta}\,(1000\,m)^2\,\frac{p_{avg}}{zN}$$

$$A = \frac{132}{0.54}\,(1000 \times 0.00375)^2\,\frac{271}{54\,(1600)}$$

$$A = 10.8$$

Now in *Fig.* 4, with $A = 10.8$ and rising to intersect the curve for $\beta = 90$ degree (corresponding to a 180-degree partial bearing or a complete 360-degree bearing since the extent of the load-carrying film is essentially the same), the value of eccentricity ratio, ε, that is obtained is 0.8. This does not agree with the first estimate of $\varepsilon = 0.7$. Repeat the process, now using $\varepsilon = 0.8$. From *Fig.* 3 for $l/d = 0.95$ and $\varepsilon = 0.8$, the value of η is 0.58. Evaluation of A from Equation 2 is then 10.0. From *Fig.* 4 with $A = 10.0$ value of ε is 0.79. This is very close to 0.8, and the calculation need not be carried further. Thus the estimated value of eccentricity ratio ε is 0.8.

The minimum film thickness, h_o, is then, from Equation 1.

$$h_o = mr\,(1 - \varepsilon)$$

$$h_o = 0.00375\,(1.252)\,(1 - 0.8)$$

$$h_o = 0.00094\text{-in.}$$

Actual measurement of film thickness, h_o and ec-

Nomenclature

A = Design factor, Equation 2
a = Distance from bearing center to journal center, in.
C = Radial bearing clearance, in. $= mr$
h = Film thickness, in.
h_o = Minimum film thickness, in.
m = Clearance modulus, in./in.
N = Angular speed, rpm
p = Average pressure per in.^{2} of projected bearing area, psi
p' = Design factor, Equation 3
R = Radius of bearing, in.
r = Radius of shaft, in.
W = Bearing load, lb
z = Viscosity, centipoise
β = Angle from line of load application to leading edge of oil film
ε = Eccentricity ratio $= a/C$
η = Side leakage factor
θ = Angle from point of minimum film thickness to horizontal centerline of bearing
ω = Angular speed, radians/sec

Fig. 7—When a bearing is extremely long, shaft deflection may create high bearing pressure at either or both ends of the bearing. Pressures in a 2-in. diameter, 5-in. long bearing, *a*, show this. Reduction of bearing length to 3 7/8 in. produced a normal pressure distribution curve, *b*

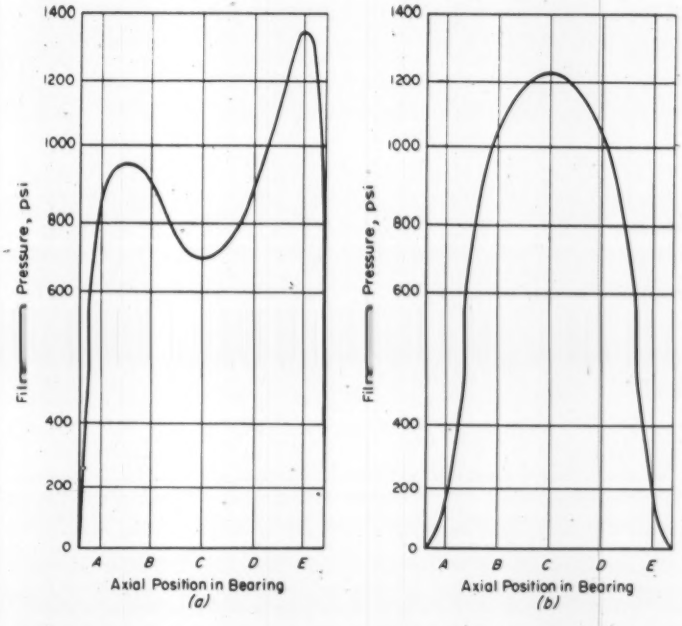
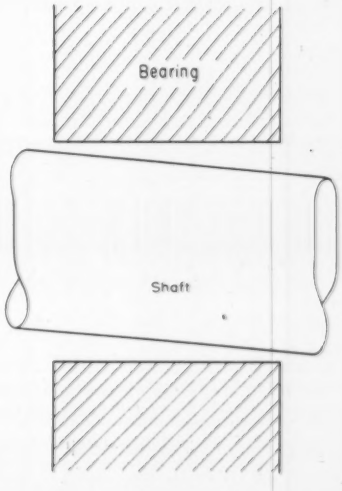


Fig. 8 — Skewing of bearing and journal can produce large reductions in load carrying capacity. A deviation of only 0.002-in. in 12 in. may reduce capacity by 30 to 40 per cent



centricity ratio, ϵ, resulted in: $\epsilon = 0.81$ and $h_o = 0.0009$-in.

EXAMPLE 2: As an example of a partial bearing, consider next a 150-degree bearing, 10 in. in diameter, and 14 in. long. There is a circumferential drainage groove at each end, ½-in. wide, and a land at the extreme end of the bearing, also ½-in., *Fig.* 5, so that the effective length of the bearing is 12 in. Speed is 1800 rpm; applied load, 36,000 lb; $m = 0.002$. If an SAE 30 oil is used and the average film temperature is 140 F, the viscosity would be 190 Saybolt Universal Seconds, or 35 centipoises. The l/d ratio is $12/10 = 1.2$. For a 150-degree partial bearing, $\beta = 75$ degrees; $p = 36{,}000/(10 \times 12) = 300$ psi.

Assume the eccentricity ratio, ϵ, is 0.6. Then from *Fig.* 3 with $l/d = 1.2$ and $\epsilon = 0.6$, η is found to be 0.58. Using this, calculate the value of A from Equation 2.

$$A = \frac{132}{0.58}(2)^2 \frac{300}{35 \times 1800} = 4.34$$

From *Fig.* 4, with $A = 4.34$, and $\beta = 75$ degrees, the value of ϵ is determined as 0.59. This is very close to the assumed value and would be considered satisfactory.

Then from Equation 1 the minimum film thickness is

$$h_o = 0.002(5)(1 - 0.59) = 0.0041\text{-in.}$$

This bearing would be running with a rather large film thickness. It could easily carry much more load under these conditions of speed, temperature, and viscosity. For example, suppose that the load were doubled, making $W = 72{,}000$ lb instead of 36,000 lb. Assume that the equilibrium film temperature rises to 170 F so that oil viscosity is 20 centipoises. First estimate of operating eccentricity ratio, ϵ, is 0.8. In *Fig.* 3, with $l/d = 1.2$ and $\epsilon = 0.8$, the value of η becomes 0.67.

Value of A from Equation 2 is

$$A = \frac{132}{0.67}(2)^2 \frac{600}{20 \times 1800} = 13.12$$

Then in *Fig.* 4 with $A = 13.12$, and $\beta = 75$ degrees, ϵ becomes 0. 86. Assumed value was initially 0.8. Therefore a second trial is necessary. Use $\epsilon = 0.85$ as the second estimate. Then η becomes 0.7, and

$$A = \frac{132}{0.7}(2)^2 \frac{600}{20 \times 1800} = 12.57$$

Then in *Fig.* 4, with $A = 12.57$ and $\beta = 75$ degrees, the value of ϵ is determined as 0.85. This is a good check. The minimum film thickness is then from Equation 1

$$h_o = 0.002\,(5)(1 - 0.85) = 0.0015\text{-in.}$$

Thus, at double the load and also reduced viscosity, the minimum film thickness is still 0.0015-in.

These examples show the type of solution that is possible if the operating film temperature is known or can be estimated. If it is, then the bearing can be analyzed as just shown. Many times however, especially with self-cooled bearings, the leveling-off temperature is not known and is a matter of calculation. This means a heat balance must be made equating the heat generated due to friction in the bearing with the heat dissipated from the bearing housing in the form of radiation, conduction, and convection. In this way, if the temperature gradient in the bearing is known, the actual operating oil film temperature can be estimated. Then the friction loss, minimum film thickness, and load-carrying capacity of the bearing will be known for those operating conditions.

Severe Operating Conditions: The method just described will be satisfactory for the majority of problems arising with industrial-type bearings. The charts cover eccentricity ratios to 0.9, and these encompass the possible operating conditions of most bearings. However, in certain industries and for a number of applications, operating conditions are so severe that an eccentricity ratio greater than 0.9 is not unusual. This could result from an excessive load, insufficient speed or a viscosity that is too low. For these extreme conditions *Fig.* 4 will not be adequate. The value of A computed from Equation 2 will be greater than 18 and thus fall off the chart. To handle problems dealing with high eccentricity ratios, a different chart is used where, by replotting with modified coordinates, the range of eccentricity ratios above $\epsilon = 0.9$ is greatly expanded. This was done by Dennison[3]. Instead of plotting against the eccentricity ratio directly, the variables are plotted against $1/(1-\epsilon)$. Thus with $\epsilon = 0.9$, $1/(1-\epsilon) = 10$. With $\epsilon = 0.95$, $1/(1-\epsilon) = 20$, and so on. The function p' is plotted against $1/(1-\epsilon)$ and

$$p' = 6.9\ (1000\,m)^2 \frac{p}{zN} \qquad (3)$$

where p is the average pressure, and all other symbols are the same as before. Values of p' in terms of l/d ratios and eccentricity ratio, *Fig.* 6, are correct for 120-degree partial bearings and can be used with partial bearings larger than this with little error, including 180-degree partial bearings and complete 360-degree bearings. The effect of side leakage is incorporated in the data through the use of a family of curves for various possible l/d ratios.

EXAMPLE 3: Consider a full journal bearing (360 degrees) which is 2½ in. in diameter by 3⅞ in. long. A steady load, W, of 3875 lb is applied. Speed, $N = 500$ rpm. Diametral clearance is 0.0064-in. SAE 20 oil is the lubricant with an average film temperature of 104 F. What is the minimum film thickness under these conditions of operation?

Average viscosity of oil film = 130 Saybolt Sec, or 23.4 centipoises. $p = 3875/(2.5 \times 3.875) = 400$ psi. Value of $m = 0.0064/2.5 = 0.00256$. Value of $l/d = 1.55$.

First, attempt to use *Figs.* 3 and 4 in this solution. Assume eccentricity ratio ϵ is 0.9. Then in *Fig.* 3 with l/d 1.55, value of η is determined as 0.8. Then A is calculated from Equation 2.

$$A = \frac{132}{0.8}\,(2.56)^2\,\frac{400}{23.4(500)} = 37$$

This value of A is completely off scale since the maximum value of A on the chart is 18. This chart cannot be used for the problem under consideration. Instead turn to *Fig.* 6. Compute p' from Equation 3

$$p' = 6.9(1000\,m)^2\,\frac{p}{zN}$$

$$p' = 6.9(2.56)^2\,\frac{400}{23.4(500)} = 1.54$$

Then, in *Fig.* 6, enter the curves with $p' = 1.54$ and move right to intersect the curve for $l/d = 1.5$. Then drop downward to read a value for $1/(1-\varepsilon)$ of 16. Then $1/16 = 1-\varepsilon$, or the eccentricity ratio $\varepsilon = 15/16$ or 0.937. Then from Equation 1

$$h_o = 0.00256\,(1.25)\,(1 - 0.937) = 0.0002\text{-in.}$$

Practical Considerations

Deformation of Bearing Shell: One of the principal causes of deviation of bearing performance from that predicted by hydrodynamic theory is lack of rigidity of the bearing shell. This lack of rigidity can be due either to elastic or thermal distortions. Larger bearings frequently suffer from lack of rigidity in their mechanical construction, and consequently they often show friction losses greater than theoretical because of deformations due to load and temperature gradients. Larger bearings are also more difficult to hold to close machining tolerances than are small bearings. This situation can be improved by using sturdier mechanical designs, by machining of higher precision, by better fitting of the surfaces, and by a definite plan for running-in the bearing before placing it in use.

Nonuniform bearing wall thickness is one of the greatest evils. Where cast bearings have nonuniform wall thickness, the different rates of cooling that result produce uneven solidification and shrinkage. Designs which include cast holes for oil supply, cooling ducts, or lugs are particularly bad. When bearings with lugs are machined to size, the nonuniform outer surfaces cannot be machined, and these hard outer surfaces may cause in time warping and distortion of the bearing. Also, when thermal expansion takes place, the solidly supported areas will be held in position while the unsupported areas will move away and not carry load. Evidence on record shows that the wear pattern for bearings with lugs on their back is decidedly spotty. Wear occurs only on the areas of the inside rubbing surface that are projections of the lugs on the back.

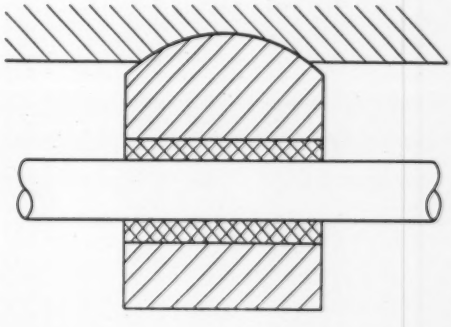
This type of wear has also been shown with precision insert-type steel-backed bearings as used so extensively in internal combustion engines. When these bearings have been assembled with a few dirt particles between the steel back of the bearing and the supporting housing, or if patches of rust have formed on the steel back, the wear pattern of these bearings when run under load will conform to the patterns of rust or the position of the dirt particles. Their effect is felt right through the steel backing and causes a corresponding distortion and rupture of the oil film. The ideal design for a bearing sleeve would have a wall of uniform thickness. A very serious error is to have the bearing and its backing too flexible.

Ring-oiled bearings should be made especially strong at the ring groove where a weak section would naturally occur. Bierbaum[6] cites an example of a bearing 6 in. in diameter by 12 in. long made with a wall only ⅜-in. thick. This was further weakened by introducing a groove ⅛-in. deep, leaving a net wall thickness of ¼-in.

The problem becomes more serious with heavily loaded bearings. Clayton[7] in testing certain bearings had to limit his operating pressures to 1500 psi, as heavier loads were found to cause serious elastic deformations. Actually, he reports that these bearings would run fairly hot under test and then a kind of mechanical creep would take place and the elastic deformation would become permanent.

Length-to-Diameter Ratio: The length of the bearing shell influences the elastic deformation of the shell when under load as well as relative deformation of the portion of the shaft that is within the bearing. If the bearing shell is long, the shaft may deflect sufficiently within the bearing to cause touching at the ends of the bearing shell. Actually, where shaft deflection is a serious problem and cannot be avoided, the ends of the bearing may be bell-mouthed to avoid rubbing contact. This is frequently done. Bradford[8] investigated these

Fig. 9—Bearing alignment can be obtained by using a spherical or cylindrical contact seat. However, friction between the seat and its mating surface prevents extremely accurate alignment



characteristics in a bearing 2½ in. in diameter by 5 in. long, with an applied load of 5000 lb, or a pressure of 400 psi. The shaft deflected in the bearing 0.00086-in. This was verified by taking pressure profiles in the oil film. They were saddle-shaped, *Fig. 7a*.

When the length of the bearing was reduced to 3⅞ in. from 5 in., making an l/d ratio of 1.55, for the same loading pressure of 400 psi, no saddle-shaped pressure distribution curve was observed, *Fig. 7b*.

Length diameter ratios are usually chosen between $l/d = 0.8$ and $l/d = 1.5$. In shorter bearings, the carrying capacity of the oil film is greatly impaired by the effect of side leakage in draining the fluid pressure. Theoretically a longer bearing would be desirable since this would reduce the effect of side leakage, but this increased length leads to reduced load-carrying capacity because of the deleterious effect of elastic deformation. Longer bearings are used, however, where alignment of the shaft is the principal objective and not load-carrying capacity. Longer bearings are used to position the shaft accurately as in spindles and machine tools in general. In power machines the tendency is toward shorter bearings. Typical values are as follows: turbogenerators, 0.8 to 1.5; gasoline and diesel engines for main and crankpin bearings, 0.4 to 1.0, with most values between 0.5 and 0.8; generators and motors, 1.2 to 2.0; ordinary heavy shafting with fixed bearings, 2 to 3; light shafting with self-aligning bearings, 3 to 4; machine tool bearings, 2 to 4; railroad journal bearings, 1.2 to 1.8.

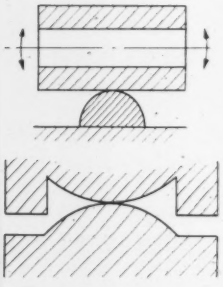
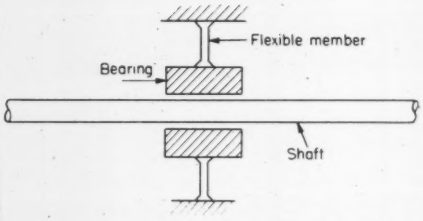


Fig. 10—Improved alignment for self-aligning bearings is obtained when contact areas are kept low to reduce friction effects. Two possibilities are shown

Fig. 11—Making bearing supports as flexible as the shaft has also been tried and found to have merit in maintaining shaft and bearing alignment



Misalignment: When the axes of the journal and bearing are skewed, *Fig.* 8, there is a resultant serious reduction in bearing performance. Pigott[9] quotes figures on misalignment in bearings to the effect that a deviation of only 0.002-in. in 12 in. can cut the ultimate load-carrying capacity by 30 to 40 per cent. Many connecting rods and main shafts have more than this amount of misalignment. In experimental studies of misalignment, variations in pressure patterns are a sensitive measure of this condition. Buske and Rolli[10] show that in a short bearing, 3 in. in diameter by 1¾ in. long, a nonsymmetrical pressure pattern could be developed by tilting one edge of the bearing by only 0.00024-in.

It is necessary to ensure that the axes of shaft and bearing are parallel to avoid end loading and wiping. This is difficult to establish and equally difficult to maintain because of the obvious elasticity of both the shaft and bearing. Wherever possible, self-aligning bearings should be used. Falz[11] describes two general types of self-aligning bearings. The first has a spherical or perhaps a cylindrical contact seat, *Fig.* 9, where sliding of the contacting surfaces must take place to ensure alignment. Frequently, because of the friction under load on these sliding surfaces, the bearing is restrained somewhat and is not as self-aligning as it should be. A second type is less dependent upon sliding friction and is designed as a tilting type where a kind of rolling takes place, *Fig.* 10. This type of loading exaggerates the tendency to distort the bearing shell elastically, and consequently the bearing housing must be made heavier and more rigid. This is, however, a very practical solution to the problem of making a bearing self-aligning.

It must be recognized that air pockets in these designs will produce an insulating effect and if

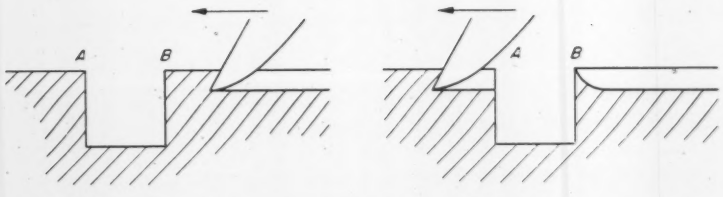


Fig. 12—Sharp edges produced by turning the inside of a bearing after it has been grooved should be removed

cooling is to be accomplished through conduction, the design must be modified accordingly. This should not be a serious consideration at moderate speeds.

Attempts to make the bearing support as elastic as the shaft and thus match the elasticity of these components to each other have been made. Such a design will ensure that no pressure concentrations will develop and the load will remain uniformerly distributed.[12] The bearing bosses are supported by thin webs or elastic plates and are free to deform and match the deflection of the shaft, *Fig.* 11.

Construction Details: Severe force fits of bearings in housings should be avoided. Even if the bearing is subsequently machined to size, creep will probably reduce the radial clearance in time. Instead the bushing should be inserted into the bearing housing with a light fit. This may be sufficient to keep it from rotating within the housing, or it may be further secured by using set screws. These screws should not touch the bottom of the hole in the bearing shell in which they fit.

In machining a plain cylindrical journal bearing to size, clamping in a chuck for this process must be done carefully. Indiscriminate clamping can cause serious distortions in the finished bearing. If possible the bearing should be machined in the end of a bar and then cut off, leaving the clamped end of the bar still in the chuck. If a bearing must be chucked it should be held as lightly as possible.

When finish-turning the inside of a bearing after it has been grooved, there is a natural tendency for a lip to spring up as the cutting tool passes over it, *Fig.* 12. The tool should be as sharp as possible but spring-back may still occur. This sharp edge on a groove is very serious and must be removed by stoning with a hand scraper or some other means.

Where case hardening is used on a shaft the case should blend as gradually as possible into the core of the shaft, so as to reduce thermal distortion and the tendency to develop high stress concentrations due to thermal action. Any checks, or rough spots, on the hard surface of the shaft will cause very rapid wear of the bearing material. The hardened surface should therefore be smooth and cleanly ground.

Shaft couplings should be carefully considered. A common fault of some couplings when transmitting torque is to become rigid axially and thus impose heavy thrust loads on bearings owing to thermal expansion in the mechanism and other causes. Rubber couplings are among those that do not develop this tendency.

Ball or roller bearings and ordinary sleeve bearings should not be used next to each other on the same shaft. Because the clearance in ball bearing or roller bearings is generally less than in sleeve bearings, the elastic action of the shaft under load will not distribute the applied load evenly over all the bearings. Those bearings with the least clearance will pick up most of the load and may, therefore, be overloaded.

Heat-dissipation properties of the bearing and its housing must always be recognized as one of the most important design aspects leading to successful bearing operation. For self-contained or self-cooled bearings, the housing and its supports should be bulky enough to have a large heat-dissipating surface. The housing of such bearings acts as a radiator to dissipate by convection and radiation the heat generated in bearing friction.

From a maintenance point of view, accumulation of oily dirt on the housing of a self-cooled bearing is very undesirable. This extra insulating layer may upset the natural heat balance of the bearing and cause overheating. Many layers of paint may accomplish the same result. The heat-dissipating action of a bearing and its housing should never be modified without serious consideration.

Clearances in Journal Bearings: Proper clearance in a journal bearing can be obtained on the basis of a complete analysis. This would include considerations of load-carrying capacity, minimum film thickness, eccentricity ratio, friction loss, oil flow, and operating temperature. As a guide, however, the following recommendations may be used.

For journals running at speeds under 600 rpm, "medium fits" may be used as defined by the American Standards Association. For journal speeds above 600 rpm, "free fits" may be used. These are specified in terms of permissible tolerances, *Table* 1. Albert Kingsbury has suggested a diametral clearance for bearings equal to $0.002 + 0.001d$. For journals running at higher speeds the diametral clearance is frequently made equal to $0.002d$ to lower the frictional losses. The most satisfactory

Table 1—Suggested Bearing Clearances

Journal Diameter (in.)	Free Fit (in.)	Medium Fit (in.)
3/16–1/4	0.0006–0.0022	0.0004–0.0014
7/16–9/16	0.0009–0.0029	0.0006–0.0018
11/16–13/16	0.0012–0.0036	0.0007–0.0021
15/16–1 1/16	0.0014–0.0040	0.0009–0.0025
1 3/16–1 5/16	0.0016–0.0044	0.0010–0.0028
1 5/16–1 7/16	0.0020–0.0052	0.0013–0.0033
1 7/16–2 1/16	0.0022–0.0054	0.0014–0.0034
2 1/16–2 3/16	0.0024–0.0058	0.0015–0.0035
2 3/16–2 3/16	0.0026–0.0062	0.0017–0.0039
2 3/16–3 1/16	0.0029–0.0067	0.0019–0.0043
3 1/16–3 3/16	0.0032–0.0072	0.0021–0.0045
3 3/16–4 1/16	0.0035–0.0077	0.0023–0.0049
4 1/16–4 3/16	0.0038–0.0080	0.0025–0.0051
4 3/16–5 1/16	0.0041–0.0085	0.0026–0.0054
5 1/16–6 1/16	0.0046–0.0094	0.0030–0.0060
6 1/16–7 1/16	0.0051–0.0101	0.0033–0.0063
7 1/16–8 1/16	0.0056–0.0108	0.0036–0.0068

Table 2—Current Practices in Bearing Design Pressures

Type of Bearing	Design Pressure (psi)
Diesel engines, main bearings	800–1500
Connecting rod bearings	1000–2000
Wrist pins	1800–2000
Electric motor bearings	100–200
Marine line-shaft bearings	25–35
Steam turbines and reduction gears	100–250
Automotive gasoline engine, main bearings	500–700
Connecting rod bearings	1500–2500
Aircraft engine connecting rod bearings	700–2000
Centrifugal pumps	80–100
Roll neck bearings	1500–2500
Railway-axle bearings	300–350
Light line-shaft bearings	15–25
Heavy line-shaft bearings	100–150

Table 3—Maximum Design Pressures for Engine Bearings*

Bearing Material	Composition of Material (%)	Maximum Mean Bearing Pressure (psi)
Lead-base babbitt	Pb (75–85), Sn (4–10), Sb 9–15)	600–800
Tin-base babbitt	Pb (0.35–0.6), Sn (86–90), Sb (4–9), Cu (4–6)	800–1000
Cadmium-base alloy	Cu (0.4–0.75), Cd (97), Ni (1–1.5), Ag (0.5–1.0)	1200–1500
Copper-lead alloy	Pb (45), Cu (55)	2000–3000
Copper-lead alloy	Pb (25), Sn (3), Cu (72)	3000–4000
Silver	Ag (99), 0.5 to 1.0 lead on surface	5000 up

*Pressures are based on fatigue life of 500 hr at a bearing temperature of 300 F. Bearing metal thicknesses are from 0.01 to 0.015-in. for lead, tin, and cadmium-base metals, and 0.025-in. for copper-lead, and silver, all on steel backs. At lower temperatures, the fatigue life will be greatly extended.

clearance should, of course, be selected based on a complete bearing analysis. For example, a design for 50,000 rpm uses a diametral clearance of 0.0025-in. with a journal 0.8 in. in diameter.

For high-speed internal-combustion-engine bearings, using forced-feed lubrication, medium fits may be used. Willi[13] recommends the following diametral clearances in inches per inch of shaft diameter for insert-bearings: tin-base and high-lead babbitts, 0.0005; cadmium-silver-copper, 0.0008; copper-lead, 0.001.

Bearing Pressures: The highest allowable bearing pressure can be determined for a given bearing in terms of actual operating conditions. The critical aspects would concern speed, temperature, viscosity, clearance, bearing metal characteristics, and minimum film thickness. A complete analysis of the bearing would soon indicate whether the selected design load was satisfactory. For example, if the minimum film thickness proved to be too small for safety and no other variables could be changed to improve operating conditions, such as increasing the speed or viscosity, the only alternate solution would be to reduce the applied bearing load or the bearing pressure.

Current practices in design pressures for journal bearings, are given by *Table* 2. Specific recommendations for internal-combustion engine bearing design are presented by Etchells and Underwood,[14] *Table* 3.

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They Say . . .

"One might have concluded a century ago that only one young man in perhaps ten million had scientific aptitudes. However, the number of scientists per million of population has, since then, grown by leaps and bounds — to 1 in 1,000,000; 1 in 100,000; 1 in 1000. And today one man in every 300 of our working population classes himself as a professional scientist; in addition, one man in every 100 is classed as an engineer. Clearly then, some scientific or engineering aptitude is to be found in about 2 per cent of the American male population. Indeed, today, out of all the men now graduating each year from our colleges and universities nearly 20 per cent take their degrees in science or engineering."—DR. LEE A. DUBRIDGE. *president, California Institute of Technology*

"As soon as engineering has better public esteem and better prestige; when it is understood that the highest qualities of mind, of public service are required of the professional engineer, then his status and incidentally his remuneration will assure adequate recruitment to the profession."—SIR VINCENT D. FERRANTI, *chairman, International Executive Council, World Power Conference*

Calculation of Beam Deflection due to shear

By H. H. Mabie
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Ithaca, N. Y.

METHODS of calculating beam deflections due to bending are well known. However, methods of calculating beam deflections due to shear are not as well known because, in the majority of applications, deflection due to shear is negligible. But in applications involving beams that are short compared to their depth, the shearing stress caused by transverse shear may be high with a corresponding high deflection. Such beams are often used in machine design. To neglect shear deflection in such cases may lead to considerable error.

This article has two purposes: (1) to focus attention on the significance of shear deflection, and (2) to present information in a graphical form that will assist the designer in determining deflection due to shear.

Two types of beams are considered: cantilever beams and simply supported beams, each with a concentrated load or with a uniformly distributed load. Three types of cross section are treated: rectangular, round and thin-walled round. Maximum deflection δ for each type of loading is given in *Table* 1. Symbols are defined in the *Nomenclature*.

The first term in the equations is the deflection due to bending. For example, for a cantilever beam with concentrated end load

$$\frac{Pl^3}{3EI}$$

Deflection due to shear is expressed by the remaining quantity. For example,

$$\frac{Pl^3}{3EI}\left[K\frac{E}{G}\left(\frac{d}{l}\right)^2\right]$$

Four series of curves, one for each type of loading, are presented in *Fig.* 1 from which one can easily determine deflection due only to shear. The ratio E/G, taken as 2.6, is an average value suitable for most metals.

To illustrate the importance of shear deflection in certain cases, consider a cantilever beam of rectangular cross section with $d/l = 0.5$ and with a concentrated load at the end. From Fig. 1 for the rectangular section ($K = 3/10$), the shear deflection factor $K(E/G)\ (d/l)^2 = 0.195$. The total deflection can then be calculated from

$$\delta = \frac{Pl^3}{3EI}(1 + 0.195)$$

It can be seen that neglecting the deflection due to shear in this case would result in an error of approximately 20 per cent.

Nomenclature

- δ = Deflection due to bending and shear, inches
- d = Depth of section, inches
- E = Modulus of elasticity in tension, psi
- G = Modulus of elasticity in shear, psi
- I = Moment of inertia about centroidal axis, inches^4
- K = Form factor, depending upon shape of cross-section and type of loading
- l = Length of beam, inches
- P = Concentrated load, lb
- W = Total uniformly distributed load, lb

Table 1—Deflection Equations

Beam Type	Load Type	Deflection, δ
Cantilever	Concentrated at end	$\frac{Pl^3}{3EI}\left[1 + K\frac{E}{G}\left(\frac{d}{l}\right)^2\right]$
Cantilever	Uniform	$\frac{Wl^3}{8EI}\left[1 + K\frac{E}{G}\left(\frac{d}{l}\right)^2\right]$
Simply supported	Concentrated at center	$\frac{Pl^3}{48EI}\left[1 + K\frac{E}{G}\left(\frac{d}{l}\right)^2\right]$
Simply supported	Uniform	$\frac{5Wl^3}{384EI}\left[1 + K\frac{E}{G}\left(\frac{d}{l}\right)^2\right]$

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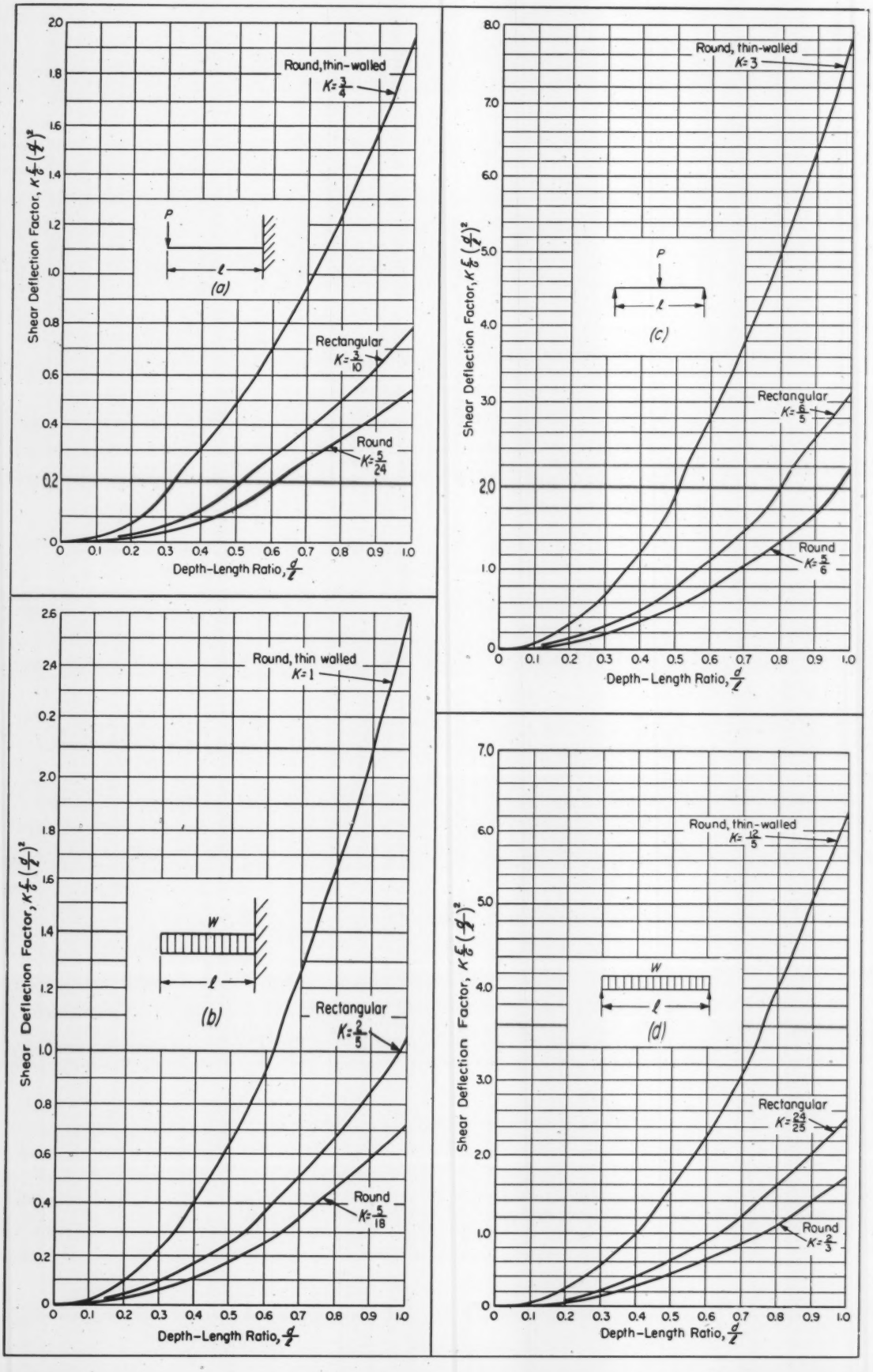
Fig. 1—Curves to facilitate calculation of beam deflection due to shear. Three common cross sections are given for (*a*) cantilever with concentrated end load, (*b*) cantilever with uniform load, (*c*) simply supported beam with concentrated load at center, and (*d*) simply supported beam with uniform load



Design considerations for

Magnesium Plaster-Mold Castings

By E. J. Willis
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Development Div.
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Cleveland

PLASTER molds for magnesium castings are made up essentially of partially dehydrated gypsum and water. The molten metal is poured into this plaster cavity. Current work has produced better tolerances and smoother physical surface conditions, as well as a reduction in cost of the final part by eliminating machining.

Size and Range of Parts: Because of the variety of parts that have been cast, the size of castings which can be made in magnesium now range from less than 1 oz to over 100 lb. At present, this range is not limited in any way, since difficulties have not been encountered, and larger castings than this 100-lb limit will probably soon be tried successfully. Castings varying from a maximum dimension as small as 1 in. to over 3 ft have been successfully made. Here again, the limitations are only from background and not from any limitation caused by the use of plaster.

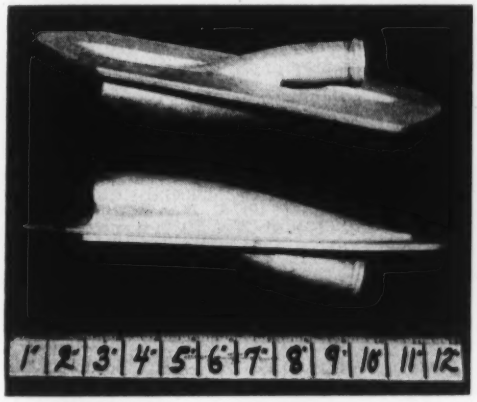

Fig. 1—Magnesium air-vent tubes produced by plaster-mold casting

Fig. 2—Aircraft control pulleys made by the plaster-mold process

Several magnesium aircraft parts produced by the plaster-mold process are shown in *Figs.* 1 and 2.

Surface Roughness: The usefulness of plaster in making molds for magnesium castings is in the production of exceptionally smooth surfaces compared with sand-cast parts. Surface finish obtained on magnesium sand castings will vary considerably from piece to piece, but in general, the surface will be between 500 and 800 microinches, unless special finishing techniques are employed. When plaster is used as the mold material, surface finishes in the neighborhood of 100 microinches are common. At the present time, finishes which range as low as 50 or 60 microinches can be found in some areas on the casting, but this smooth a finish on all surfaces should not be specified. Where agreement can be reached between the casting user and the foundry, exceptional-

ly smooth surfaces in specific and limited areas can be obtained. These special requirements should be indicated on the drawings.

Castable Magnesium Alloys: All normal magnesium alloys which may be sand-cast can be cast equally well in plaster molds. In addition to these standard alloys, the usefulness of the process may extend itself to both magnesium rare-earth zirconium and the magnesium-thorium-zirconium alloys if the demand for high-temperature castings to close tolerance and smooth finishes continues. Many jet-engine and guided-missile applications may soon require these alloys for proper functioning of the machines.

Dimensional Tolerances: Two typical sections through castings produced in plaster are shown in *Fig.* 3. This shows the necessary parting lines, draft, and thickness relations. Dimension *A* is taken across the parting line where there are two mating mold pieces. A tolerance at this point of plus or minus 0.010-in. for the first inch or less and an additional 0.001-in. for each additional inch of length should be added. Dimension *B*: Between points produced by any one part of the mold, a tolerance of plus or minus 0.005-in. for the first inch or less and an additional 0.001-in. should be added to this tolerance for each additional inch of length. Dimension *C*: Between points produced by a core in the mold, tolerances of plus or minus 0.010-in. for one inch or less plus an additional 0.001-in. for each additional inch. Dimension *D*: The maximum length of core supported at one end is normally five times the diameter of the core, where, if the core is supported at both ends, the lengths of a small-diameter core may be as much as ten times the diameter.

Dimensions *E*, *F*, and *G*: At many points in castings using plaster cores and plaster molds, zero draft is permissible. This is especially true in local areas; however, as a general rule, 2 degrees is a desirable amount.

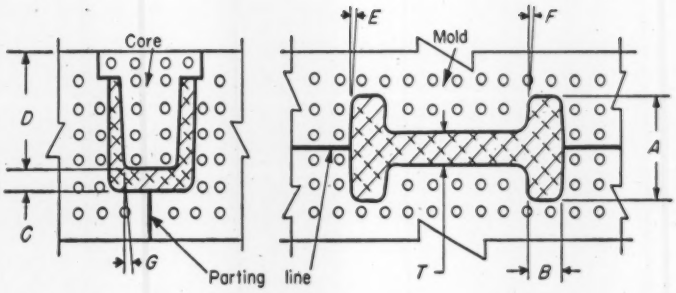

Fig. 3—Two typical sections through plaster-mold castings to illustrate tolerances

As far as general rules are concerned, the minimum diameter of separate cores should be approximately ¼-in. Minimum thickness shown as dimension *T* in *Fig.* 3 should be considered as about ⅛-in. over any 6-in. linear dimension. In local areas, where an area does not exceed about 30 sq in. or 3 to 6 linear in., thicknesses as low as 3/32-in. can be tolerated. There have been some castings where very small local areas need to be very thin, but are fed easily by surrounding thicker sections, and 1/16-in. thickness can be produced.

When plaster is used in conjunction with the sand-cast process to obtain local dimensional advantage, the areas of the casting produced by the plaster should be used for set-up purposes in machining. Both internal radii and external radii can be reduced considerably over sand-cast magnesium. Sharp corners can be cast with the plaster process when required.

As the use of plaster-mold castings in magnesium becomes better known, plaster will be used in conjuction with the sand-cast processes as well as in conjunction with permanent-mold castings. From an economical standpoint, plaster-mold castings will be considerably more expensive than green-sand and should be used only where the specific advantages of the plaster process are important. These advantages include the ability to produce detailed lettering or markings on castings, local smoothness for air flow or oil flow, and close dimensional tolerances for reduced machining or hand work in finishing. Much thinner sections can be produced when using plaster cores in combination with other mold materials such as sand or permanent molds. The mechanical properties of composite plaster and sand castings will be better than plaster alone can produce.

Mechanical Properties: Some of the differences between magnesium plaster castings and sand castings should be mentioned. Much of the work so far has been on castings with relatively thin sections, sometimes with special dimensional tolerances and special surface conditions. For this reason, mechanical properties surveyed are relatively limited. Using AMA263-T6 as the alloy for comparison, results indicate the same yield strength as sand-cast AMA263-T6 (19,000 psi) can be obtained, but the tensile strength and elongation are slightly less in plaster. These results are based on a test-bar diameter of ½-in. In thinner sections, this difference will decrease considerably, while in thicker sections there will probably be few cases where both sides of the section will be produced in plaster. The additional chilling effect of the sand will reduce these differences.

From a paper entitled "Magnesium Plaster Mold Castings" presented at the 11th Annual Convention of the Magnesium Association in New York, October 1955.

Application factors for

Small Gas Turbines

By Henry C. Hill
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THE small gas turbine is necessarily a high-speed machine. The smaller the physical size of the engine, the higher will be the rotor speed, in a fairly well-fixed mathematical relation. Rotor speeds for the horsepower output range of 100 to 400 hp are in the 30,000 to 50,000 rpm range — a very marked change from piston-engine shaft speeds. Even though some of the small piston engines in the less than 50 hp class, such as outboard engines, have achieved the rated speed of 10,000 rpm, it is interesting to note that this is less than the idle speed of the 175-hp Boeing turbine, which is 15,000 rpm.

A schematic diagram of the Boeing model 502 turbine is shown in *Fig.* 1. *Fig.* 2 is of a cutaway engine showing the independent gas producer and output turbine rotor. Many of these engines are in active service, in the Navy as generator power plants in mine-sweeper service, *Fig.* 3, and the Air Force as air-compressor ground starting units for large jet and turboprop aircraft engines, *Fig.* 4.

The service record of these engines has been good. Even more important, they have demonstrated

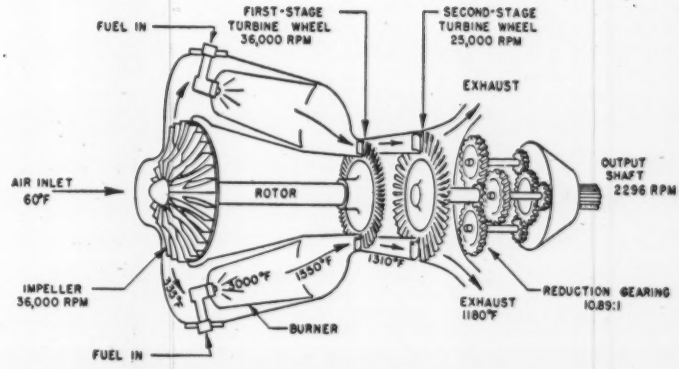

Fig. 1—Schematic diagram of Boeing model 502 gas turbine

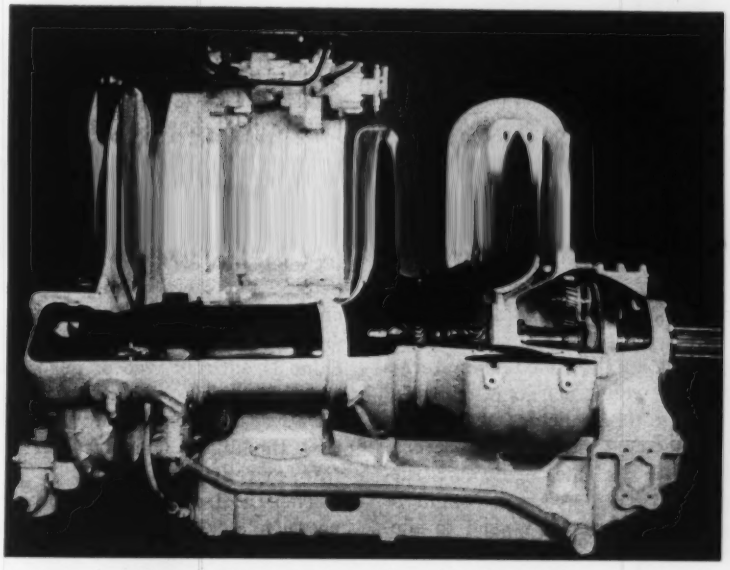

Fig. 2—Cutaway view of model 502 turbine

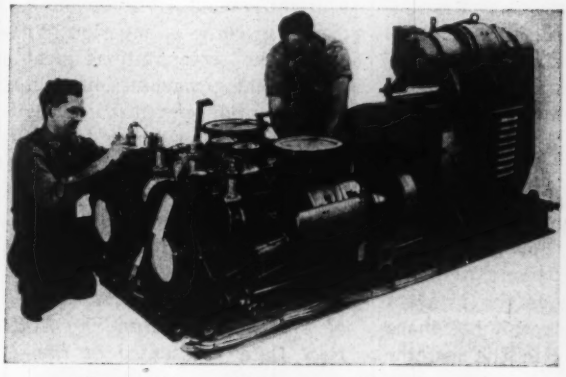

Fig. 3—Navy MSB twin-turbine-powered generator set

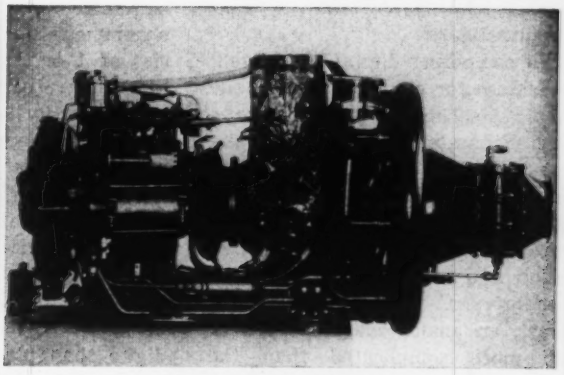

Fig. 4—Air Force gas-turbine-powered air compressor

that their operating life is comparable with the best contemporary gasoline and diesel engines.

Substantial improvement has been accomplished in making rotor blades more resistant to damage from foreign material by redesign of the airfoil for thicker and blunter edges and lesser operating stresses, and by change to alloys with greater hot strength and fatigue resistance.

Work on burner development has not by any means reached the possible ultimate in carbon-free operation but has opened up new avenues for further improvement. Future possibility of completely carbon-free burning, and also successful use of fuels of considerably lower grade, and lower cost, than automotive diesel fuel are evident. Reliable and long-life plain journal and thrust bearings should alleviate present high-cost balancing operations in the factory and in service operations. With the far greater turbine blade durability already established, the gas turbine can set new standards of reliability and life.

From a paper entitled "Small Gas-Turbine Development" presented at the Symposium on the Role of the Small Gas Turbine Engine, in New York, October, 1955, under the auspices of Polytechnic Institute of Brooklyn; ASME and SAE.

Comparing Digital and Analog Computers

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New York

THERE are two general types of computing machines, analog and digital. The analog computer is a physical analogy to the type of problem its designer wishes to solve. Information is supplied to the machine in terms of the value of some physical quantity. The machine transforms this physical quantity in accordance with the rules of its construction. A typical example would be an electrical network used to simulate a complex pipeline distribution system. Current flow would be analogous to fluid flow, and the economics of changes in the distribution system may quickly be investigated.

In comparing digital and analog machines for simple problems, the analog machine is almost always less elaborate. Even the most elementary digital computer requires an arithmetical unit, a control unit, a storage unit, an input device for basic data and instructions, and an output device for interpretation of results. In contrast, an analog machine need be no more complicated than the problem demands. A slide rule, for example, is a perfectly respectable information machine of the analog type.

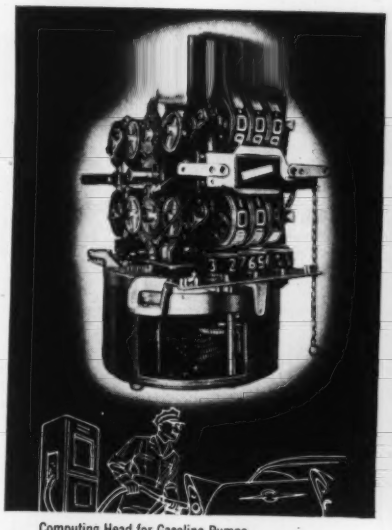
As problems become more complex, the analog machine loses its initial advantage. Since it is a physical analogy of the problem, the more complicated the problem, the more complex the machine must be. Random electrical disturbances always occur in electrical circuits, and in the more complex analog machines these disturbances have an adverse effect on the accuracy of the results. This places a practical limit on the complexity of an electrical analog computer. The digital machine is entirely free of such hazards. There is no intrinsic limit on the complexity of problems that the digital machine can perform or control.

The third important difference between analog and digital machines is their accuracy potential. The precision of the analog machine is restricted by the accuracy with which physical quantities can be handled and measured. It is not uncommon to speak of inaccuracies of 1 or 2 parts per 100, but in the more complex units the inaccuracy may be much more than this. This is one of the more limiting disadvantages that analog computers have in the field of scientific computations. On the other hand, a digital machine which deals only with discrete numbers can be as precise as the problem demands. When a result has more digits than places in the counter in a machine, "rounding off" must be done even in a digital machine, but the usual condition is for the result to contain more digits than are needed.

There is yet a fourth respect in which the two machines differ. An analog computer works in what is called "real time," that is, it continuously offers the solution to the problem that it is solving, and this solution is appropriate at every instant to all of the information which has so far entered the machine. This property of working in "real time" is very important in most problems of automatic control. Some of the modern digital machines can achieve the necessary speed to work in "real time" for the control of aircraft, but they are not fast enough to deal with the problem of simulating the flight performance of a guided missile.

In simple applications, in which no great precision is required, an analog computer will usually be preferable. For complex problems, or problems in which a high degree of precision is required, a digital machine is superior. Where "real time" computations must be made, analog machines are almost always used now, though digital machines are beginning to achieve speeds to fit them for this type of application. A digital type of computer is the most desirable for statistical and engineering applications.

From a paper entitled "The Use of Computers in Handling Statistical Data" presented at the Annual Meeting of ASEE, Chemical Div., at Penn State University, June, 1955.



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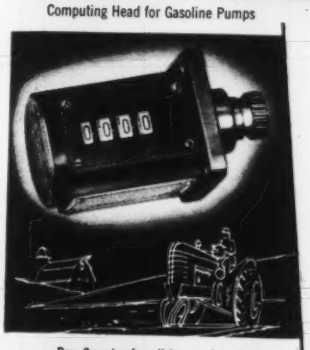

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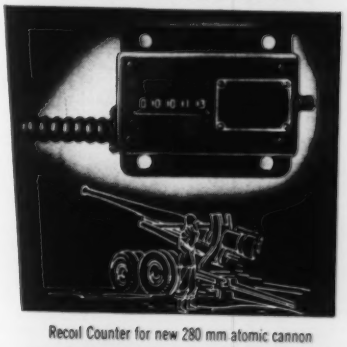

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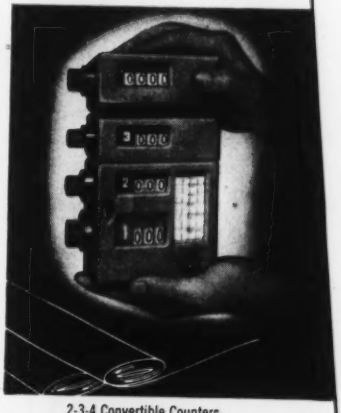

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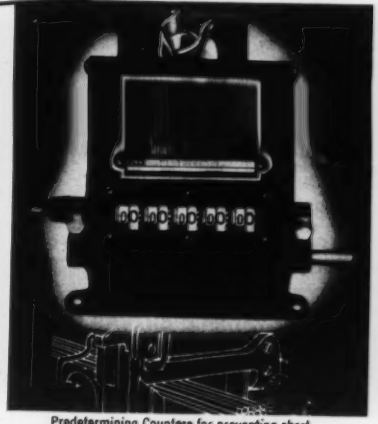

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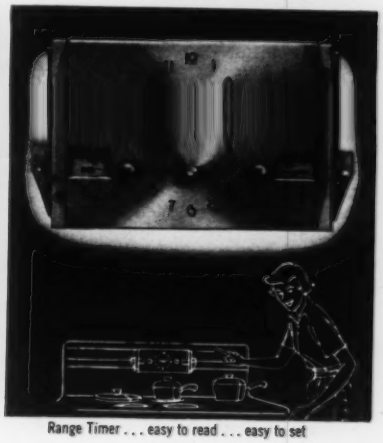

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—Circle ITEM 3

Speed Controls

Speed-sensitive switches and governors which are designed for precision control in range of 500 to 10,000 rpm are described in bulletin 504S. Operating on flywheel principle, these devices provide overspeed protection as well as regulation of engines and other rotating machinery. Price lists are included for overspeed and underspeed governors and switches. 10 pages. Synchro-Start Products, Inc.

—Circle ITEM 4

Servo-Computor Potentiometer

The 400-cycle Vernistat is an alternating current potentiometer for use in servo systems and analog computers. It combines the features of a potentiometer and a variable autotransformer. This device for relating mechanical shaft rotation to electrical voltage is detailed in illustrated brochure. 4 pages. Perkin Elmer Corp.

—Circle ITEM 5

Two-Hand Clutch Controls

Catalog 65 describes line of Micro Switch trip controls for electric two-hand control of clutches of industrial machines such as punch presses and bending brakes. Related control components are covered to fit any type of machine. 12 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div.

—Circle ITEM 6

Thermocouple Data

Both the design and selection of thermocouples for liquid, gas and surface temperature measurements are discussed in series of four bulletins 1601, 2, 3 and 4. Information is included on conductors, junctions, tubes and related items. 14 pages. Revere Corp. of America.

—Circle ITEM 7

Toggle Switch Seal

Design and performance characteristics of the model 3268 silicone rubber panel seal for water, dust and moisture-proofing panel-mounted toggle switches are contained in illustrated data sheet. 1 page. Panseal Inc.

—Circle ITEM 8

Do You Use Set Screws?

List prices and full technical and dimensional data on Zip-Grip, offset, Jail-Lok, Super-Tork, hopper type, Nu-Cup, fluted, Pre-Tork and Jam-Lok set screws for practically every purpose are contained in Catalog No. 19. 24 pages. Set Screw & Mfg. Co.

—Circle ITEM 9

Heat in Hydraulic Circuits

"Heat, Its Generation and Natural Dissipation in Hydraulic Circuits" is a technical article dealing with heat transfer area, oil circulation rate, auxiliary pumps, power pumps, pipes and valves. Test results are charted. 8 pages. Oilgear Co.

—Circle ITEM 10

Electric Counters

Electrically operated counters with life ratings up to 200 million counts are detailed in catalog E 100. Standard, panel mount and dustproof types are available for operation on up to 220 v ac or dc. A wide selection of actuators adapts them for every purpose. 8 pages. Production Instrument Co.

—Circle ITEM 11

Data on Sprayed Metal

The applications of metallizing or sprayed metal in the production of electrical and electronic equipment are subject of bulletin 120. Originally used to provide a soldering base on nonmetallic materials, this process is now being used for shielding, making electrically reflective surfaces and replacement of wired circuits. 6 pages. Metallizing Engineering Co.

—Circle ITEM 12

Expansion Literature

"Dodge Expansion Insert" is an illustrated bulletin that describes this threaded insert for installation in plastic parts, die castings and other materials after parts are molded. Applications, specifications and prices are included in accompanying literature. 4 pages. Phelps Mfg. Co.

—Circle ITEM 13

Aluminum Alloy Selector

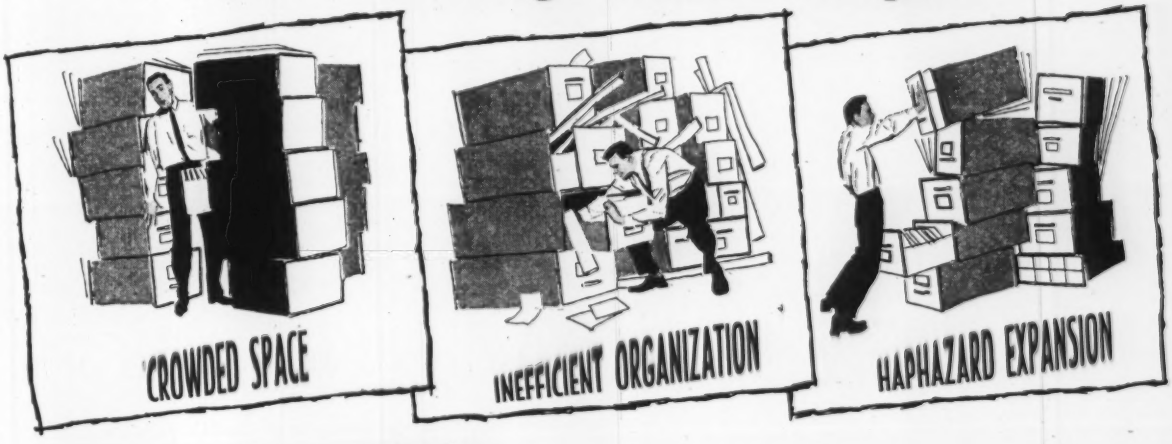
Specifications for every major aluminum alloy and condition used in sand mold and permanent mold casting processes are readily obtained with slide-rule type calculator. Specifications, physical properties, compositions and other data are available with simple settings. Rule condensed information contained in many pages of engineering manuals. Howard Foundry Co.

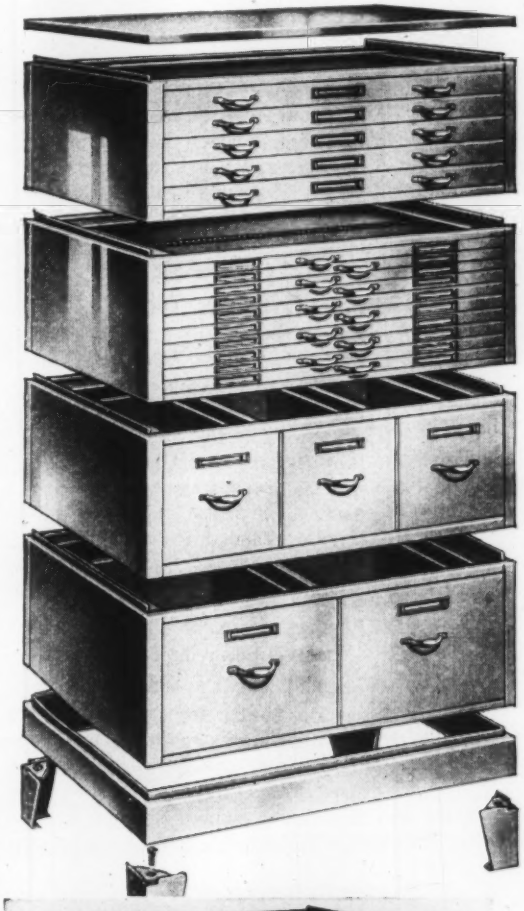
—Circle ITEM 14

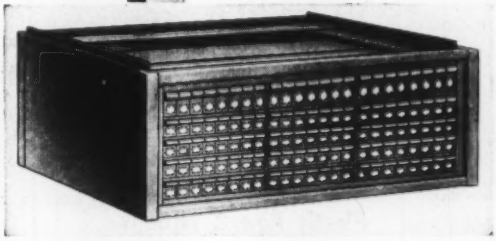
Custom Teflon Parts

Graphic illustrations of the various applications of Du Pont Teflon as cup, ball or shaft seals; washers; gaskets and diaphragms are pre-

Don't Let These Filing Bottlenecks Stall Drafting Room Output!







File units for roll tracings are available. Individual trays protect each roll from dirt, tearing, and crushing.

Let Your Bruning Man Show You How a Hamilton UnitSystem

Saves Space and Time, Permits Orderly Expansion

UnitSystem is Integrated to Save Time and Space. UnitSystem offers you an integrated and interlocking stack in which your drawings and records are filed in units especially designed for them by size and frequency of use. Drawings are easier to file and find, which saves time. The interlocking feature lets you combine the individual units you need—in higher stacks—which saves space.

The Shallow-Drawer Unit with special tracing lifters makes any active tracing easily accessible without risk of damage to companion tracings. Vertical Filing Unit with index binders and compressors keeps active small sheets straight and upright without wrinkling or tearing. Five-Drawer Unit provides ideal storage for semi-active or inactive drawings and records by groups or projects.

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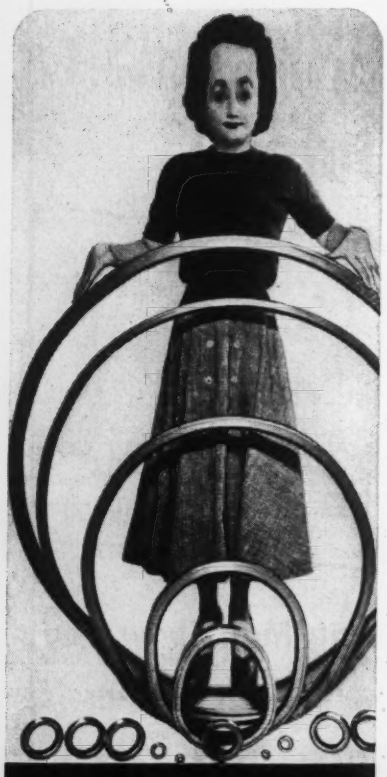
Company_____

Address_____

City_____ County_____ State_____

—ITEM 217—



FOR LARGE OIL SEALS IN SMALL QUANTITIES AT THE LOWEST COST SEE

Universal

Universal's unique manufacturing method which eliminates tooling charges for unusually large diameter oil seals is ideal for experimental and small quantity orders.

Precision-built to give long, efficient, trouble-free service—all Universal Oil Seals 'specially engineered for floatability, self-alignment and automatic take-up.

Oil seals for every purpose!

UNIVERSAL OIL SEAL CO.

P.O. BOX 74
PONTIAC, MICH.

—ITEM 218—

Helpful Literature

sented in illustrated brochure "Sparta Reports on Custom Molded Teflon." This tetrafluorethylene resin withstands severe temperatures and corrosion. Sparta Mfg. Co.

—Circle ITEM 15

Spring Design Considerations

Third in a series of data sheets dealing with basic considerations in the design of precision springs, section 1A covers residual stresses, stress concentration, fatigue life and effects of high temperatures. 10 loose-leaf pages. Hunter Spring Co.

—Circle ITEM 16

Data on Hydraulic Cylinders

Heavy duty 2000-psi rated hydraulic cylinders in 1½ through 12-in. bores, with up to 22-ft strokes and 19 different mounting styles are subject of illustrated bulletin H-104K. Engineering, design and application data are included. 8 pages. Miller Fluid Power Co.

—Circle ITEM 17

Mobile AC Power Unit

The Mo-Bil-Ac is a mobile power supply unit which delivers up to 10 kw at standard voltages and frequencies. Compact units can be incorporated in OEM designs or existing equipment. Ask for bulletin C-10. 8 pages. Miehle Printing Press & Mfg. Co., Star-Kimble Motor Div.

—Circle ITEM 18

Quick-Connect Coupling

Details, engineering data and specifications of type H quick-connect, quick-disconnect couplings for hydraulic and high pressure systems are given in bulletin 240 and data sheet 241. They have positive two-way seal when disconnected. 4 pages. Snap-Tite, Inc.

—Circle ITEM 19

High Temperature Grease

Data on Sun 844X grease which can be used at temperatures up to 250°F are given in illustrated bulletin 40. Characteristics, application methods and other information are included. 1 page. Sun Oil Co.

—Circle ITEM 20

Lubricating Pumps

Four bulletins 5531, 5533, 5535 and 5537 describe double-acting hydraulic, single-acting hydraulic, single-acting pneumatic and cam-driven mechanical pumps which are designed for automatic lubrication service. 2 pages each. Trabon Engineering Co.

—Circle ITEM 21

Prefinished Metal Strip

A rainbow of permanent prefinished colors is obtainable in Colorweld aluminum, steel and other metal coiled strip up to 36 in. wide. Material can be blanked, formed or otherwise processed without damage to the finish. Full information on this versatile material is contained in illustrated bulletin. 4 pages. Southern States Iron Roofing Co.

—Circle ITEM 22

Aluminum Mill Products

Extruded shapes, structurals, machining stock, drawn tube, forging stock, press forgings, impact extrusions, screw machine products and heavy press extrusions are some of the wrought aluminum mill products that are detailed in illustrated booklet "Aluminum Products." 8 pages. Harvey Aluminum.

—Circle ITEM 23

Heat Exchanger Tubes

Pertinent data on popular grades of carbon, alloy and stainless steel heat exchanger tubing, both seamless and welded, are contained in bulletin TB-329B. Installation of heat exchanger and condenser tubes by the expanding method is explained. 8 pages. Babcock & Wilcox Co., Tubular Products Div.

—Circle ITEM 24

Plastics & Resins Data

"1956 Condensed Reference File of Bakelite Plastics and Resins" presents up-to-date information on properties and uses of these materials. Design and production guidance is also offered. Typical products are shown. 12 pages. Bakelite Co.

—Circle ITEM 25

Sheet Metal Fabrication

Typical sheet metal fabrications this company's Fabrication Div. can make are illustrated on this sheet. 2 pages. Industrial Equipment Co.

—Circle ITEM 26

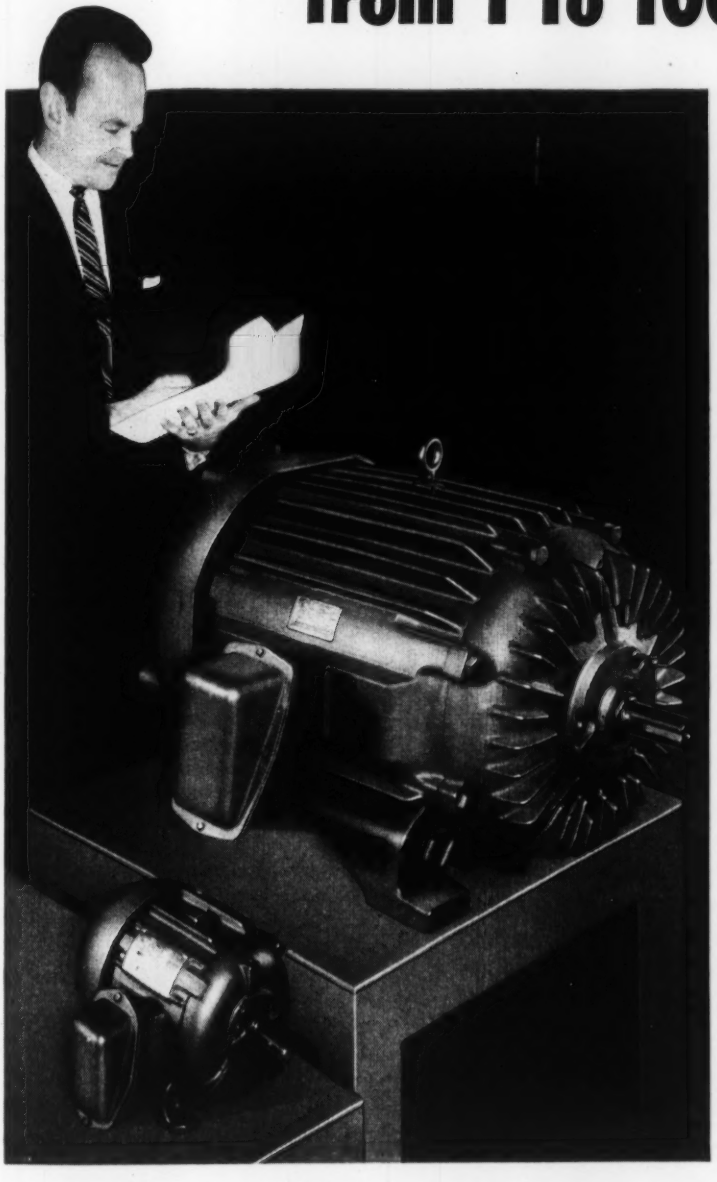
Plastic Pipe & Fittings

Physical properties, applications and specified dimensions of Corning brand polyvinyl chloride pipe and fittings for conveying corrosive mod-

There's **MORE** rating selection available in Allis-Chalmers **MOTORS**

To meet design needs...

Allis-Chalmers Offers Complete Line of Rib-Type MOTORS from 1 to 100 Hp



Allis-Chalmers, a pioneer in rib-type TEFC motor design, is the only leading manufacturer offering a complete line of these motors from 1 to 100 hp. The many cost-saving features of deep-rib construction can be applied in a variety of uses... both indoors and out.

Here's why these motors pay dividends:

MORE cooling surface — Rib-type design provides reserve cooling capacity in dirty locations.

MORE iron—Cast-iron frame and external parts assure rigidity and resistance to corrosion.

MORE copper — Allis-Chalmers greater use of copper increases electrical life.

MORE lubrication provisions — Large grease reservoirs surround bearings. Provision made for in-service relubrication — important where moisture or corrosive vapors contaminate grease.

As a new machinery component or as replacement, specify Allis-Chalmers. To find out more, contact your nearby Allis-Chalmers distributor, district office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

A-4941

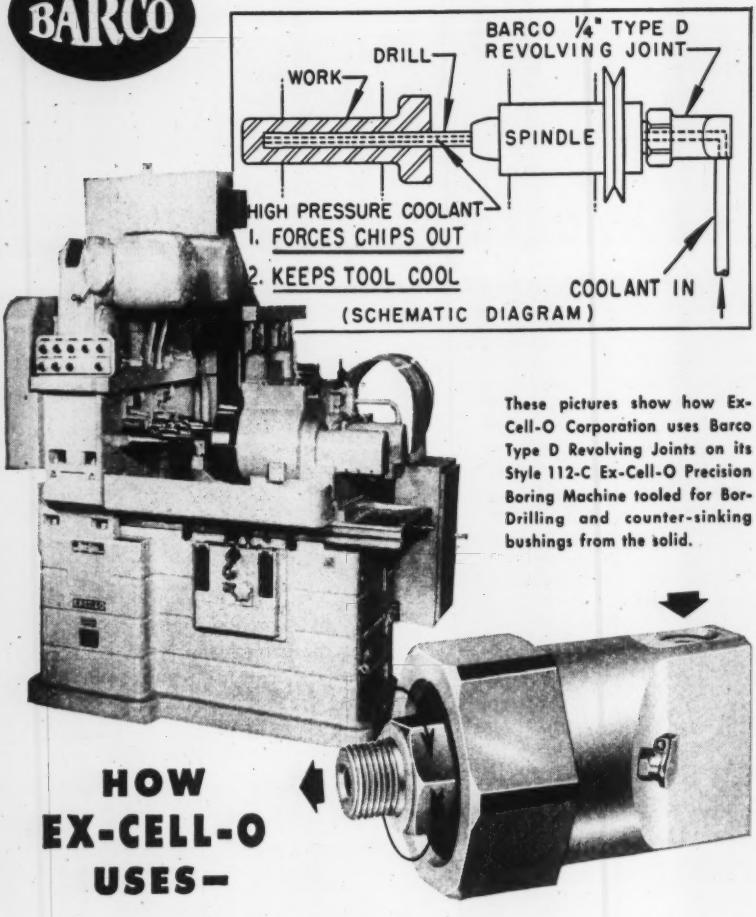
ALLIS-CHALMERS

A-C ALLIS-CHALMERS

—ITEM 219—

For More Information Circle Item Number on Yellow Card—page 19

BARCO



These pictures show how Ex-Cell-O Corporation uses Barco Type D Revolving Joints on its Style 112-C Ex-Cell-O Precision Boring Machine tooled for Bor-Drilling and counter-sinking bushings from the solid.

HOW EX-CELL-O USES—

New High Speed Barco Revolving Joints

for speeds up to 10,000 RPM

BARCO'S new, high speed Type D Revolving Joints are especially designed for machine tool installations. Ex-Cell-O Corporation uses them to introduce coolant under high pressure through the spindles and Bor-Drills of the machine shown above to force out chips and keep the drills cool (see sketch). Barco's Type D Joints are well-suited for this application because of their precision construction and compact design. Exclusive seals are self-adjusting for wear and permit operating speeds as high as 10,000 RPM on coolant service. Joints can be used on pressures to 300 psi (air) or 1500 psi (hydraulic). Temperatures from −20° to +225°F. For complete information, write BARCO MANUFACTURING CO., 506 C Hough Street, Barrington, Illinois.

BARCO

THE ONLY TRULY COMPLETE LINE OF FLEXIBLE BALL, SWIVEL, SWING, AND REVOLVING JOINTS

—ITEM 220—

Helpful Literature

erate-temperature liquids are tabulated in bulletin PE-40. This pipe can be cut, sawed and threaded with standard pipe tools. 12 pages. Corning Glass Works.

—Circle ITEM 27

Flow Control

Performance and application information on the Electro-Mesurflo valve for medium flow volume control service is presented in illustrated bulletin 231. Sizes are available for 0.2 to 8 gpm. 8 pages. Hays Mfg. Co.

—Circle ITEM 28

Impedance Plotter

The Automatic Impedance Plotter is described as an automatic recording device for plotting complex impedance versus frequency or other variables in illustrated bulletin. Details of instrument and typical charts are included. 12 pages. Chesapeake Instrument Corp.

—Circle ITEM 29

Motor Library Service

A reference library service covering over 900 special design motors of every conceivable size and shape is now available to original equipment manufacturers and other motor users. Library will help save expense and delay of special-motor development. Sample units for test running of equipment are offered. Reuland Electric Co.

—Circle ITEM 30

Thermocouple Wire Data

Conductor specifications and recommended insulations for various operating temperatures of standard thermocouple wires are listed in engineering bulletin 1701. Bulletin includes thermocouple wires built to military specifications, data on wire resistances, weights and electromotive forces. 12 pages. Revere Corp. of America.

—Circle ITEM 31

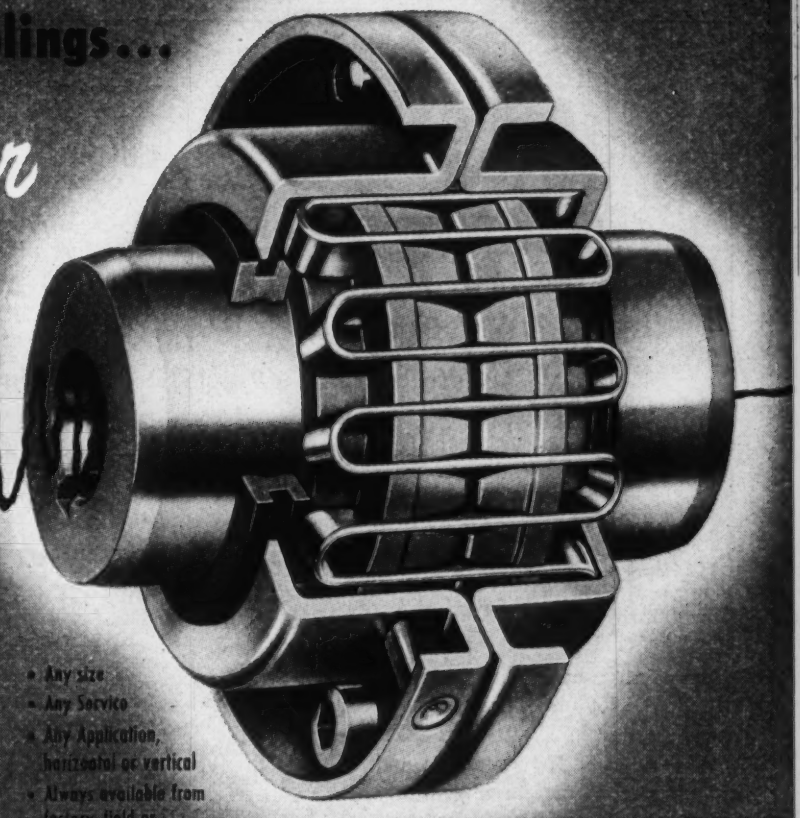
Electric Cord Attachments

Stock molds for caps, connectors, strain-reliefs and other special cord attachments are listed in catalog 5-55. Types and sizes are recommended for wide range of uses on power tools, appliances, office equipment, lighting and other electrically powered equipment. 10 pages. Royal Electric Co.

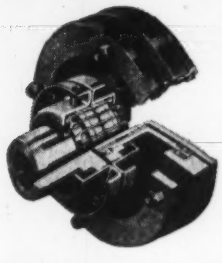
—Circle ITEM 32

Falk Steelflex Couplings...

Protect your machinery in 2 ways



- Any size
- Any Service
- Any Application, horizontal or vertical
- Always available from factory, field or distributor stocks

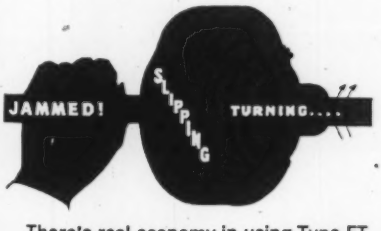


Falk Controlled Torque Couplings prevent damage from overloads

In applications where danger from overloads exists, use the FALK Type FT Controlled Torque Coupling. The Type FT has all the features and advantages of standard FALK Steelflex couplings—and, in addition, has an adjustable friction slip clutch, enabling the operator to set the coupling to slip at any predetermined overload.

This controlled-torque principle not only prevents transmission of dangerous shocks and limits overloads; it eliminates the breaking of shafts caused by jamming of driven equipment.

An outstanding advantage of the Type FT Coupling is that, as soon as the cause of the overload is removed, the entire coupling will rotate and transmit power without replacing parts or repairing coupling.



There's real economy in using Type FT Controlled Torque Couplings. Many users have reported that these couplings paid for themselves the very first time they slipped (under overload) because of the protection against damaged driving or driven machinery!

...cost less per year of service!

You get *double protection* when you connect your driving and driven machinery with a Falk Steelflex Coupling—the all-steel coupling with the exclusive grid-groove design! First, its *torsional resilience* smothers shock and vibration; and second, the Steelflex design prevents damage and lowered efficiency by accommodating shaft misalignment.

Why have increasing numbers of key men in industry standardized on Falk Steelflex Couplings? Their experience has proved that Falk Steelflex Couplings prolong the service life of their machinery... are trouble-free and need minimum maintenance . . . are easy to install, lubricate and disconnect . . . and *cost less per year of service* than ordinary couplings.

One basic Steelflex design—the type F, in its many sizes—is adaptable to more than 90% of all industrial applications. For applications involving danger from overloads, Modified Type FT Controlled Torque couplings (see column at left) are ideally suited. There are numerous other special or dual purpose Steelflex couplings for unusual applications. **Write to Department 247** for engineering bulletin, including selection and dimension tables.

THE FALK CORPORATION, MILWAUKEE, WISCONSIN

FALK

...a good name in industry

MANUFACTURERS OF:

- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

XUM

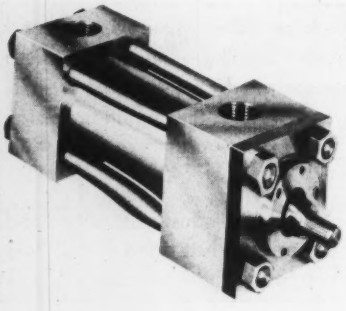
NEW PARTS AND MATERIALS

Use Yellow Card, page 19, to obtain further information

Hydraulic Cylinder

suitable for severe duty at pressures to 2000 psi

Heavy-duty hydraulic cylinder, rated at 2000 psi, is available in bore sizes from 1½ to 8 in. The cylinder meets JIC standards and is intended for use in severe duty industrial operations. Pressure sensitivity and long life are assured by the multiple-lip, self-compensating rod packing, which is contained in an easily replaceable cartridge. Piston rods are hard-chrome plated, high tensile steel, and seamless cylinder walls are



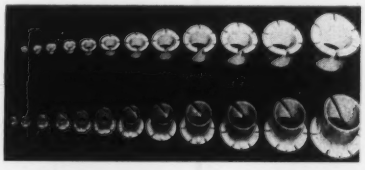
micro-honed to minimize friction. Recessed heads confine the tube and prevent leakage and breathing in high-pressure service. **Ortman-Miller Machine Co.**, 7 143rd St., Hammond, Ind.

—Circle ITEM 61

Nylon Flange Bearings

are slotted to prevent shaft binding

Slots in the flanges and liners of Nyliner bearings permit change in their circumference with heat or moisture absorption without affecting the bore size. Standard types 5 and 6 are identical except for an antirotation key in type 6, shown in the lower portion of the illustration. The key prevents rotation of the bearing, which can cause wear in soft, nonferrous housings. Flange can take thrust loads and frequently is sufficient to retain the bearing in the housing. Twelve standard sizes are available, ranging from 3/16-in. to 1½ in. ID. **Thomson Industries Inc.**, Manhasset, N. Y.

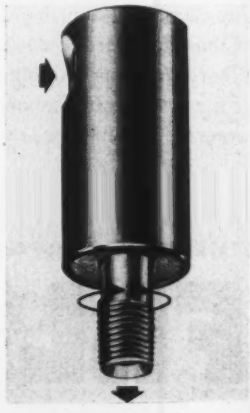


—Circle ITEM 62

Swivel Joint

for pressures to 2000 psi

Single-plane swivel joint, designed for hydraulic or pneumatic service, provides up to 360 deg rotation on pipe, tubing, or hose. For use on machinery requiring flexible connection, it eliminates sharp hose bends and relieves twisting



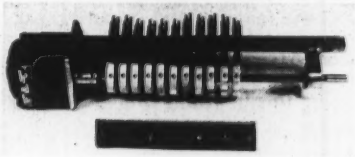
stresses. Ball bearing and thrust bearing types are made for pressures up to 2000 psi and temperatures ranging from −20 to 225 F. Equipped with O-ring seals, the joint requires no lubrication in normal service. Standard sizes are ¼ and ½-in.; ⅜ and ¾-in. joints are available on quantity orders. **Barco Mfg. Co.**, 500 N. Hough St., Barrington, Ill.

—Circle ITEM 63

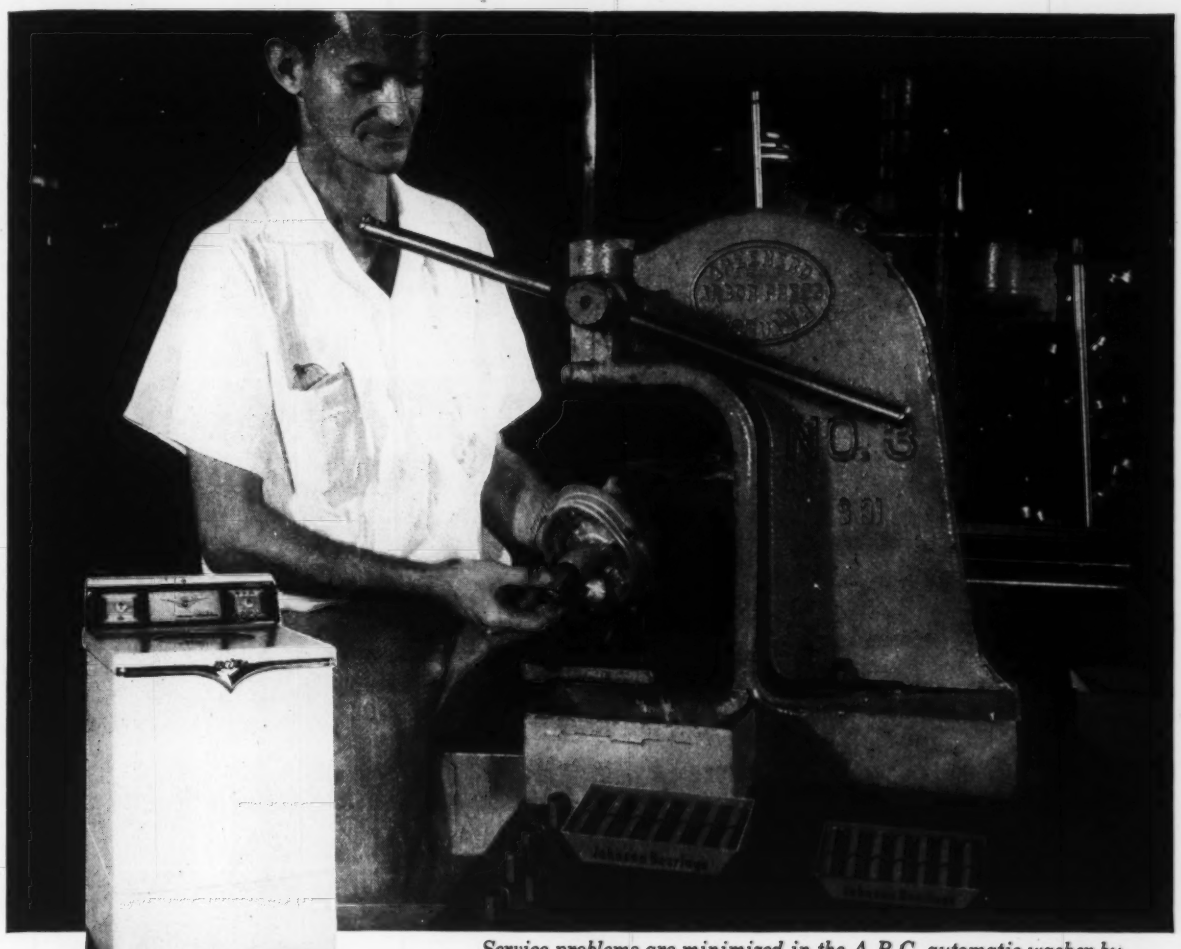
Motor-Driven Interrupter

has nylon cams and followers for quiet operation

Either 1 to 6 or 7 to 16 circuits are accommodated by two models



of type BC motor-driven interrupter. Designed for automatic control or similar applications, unit has 115 v, 60 cycle drive motor with internal gear reducer. Windings for other voltages and frequencies are available, and shaft speeds from 1 to 15 rpm or higher can be specified. Cut to order, machined nylon cams have guaranteed accuracies of ±1.5 deg for any point on a single cam; accuracy between points on any two cams is ±2.25 deg. Telephone-type spring pile-ups are available in seven contact arrangements and are actuated by nylon followers for long life and quiet operation. Rating of platinum-iridium contacts is 2 amp for 115 v ac, resis-



Service problems are minimized in the A.B.C. automatic washer by use of Johnson sintered bronze Ledaloyl self-lubricating bearings.

Altorfer Brothers Company assures customer satisfaction by using Johnson Bearings in its A.B.C. Washers

One way that Altorfer Brothers Company, Peoria, Ill., manufacturer of the A.B.C. line of washers, ironers and driers, gets assurance of customer satisfaction is to install the finest bronze bearings available. Altorfer uses powdered bronze bearings made by Johnson Bronze Company of New Castle, Pa., because they are carefully produced to exact specifications and because they retain enough oil to service the bearings during the life of the washer.

Consider the Ledaloyl sintered bronze bearings which Johnson Bronze makes for use on the A.B.C.-O-Matic washer's shaft and tube. This bearing, one of eight sintered bronze bearings, is the workhorse of the washer and is vital to the operation of the shaft which spins the tub. Johnson Bronze Company has supplied these bearings to Altorfer Brothers since 1950 when the firm first began to make automatic washers.

Altorfer Brothers has used Johnson bearings for other applications since 1928 because of their uniform high quality.

If you have a tough application that calls for long bearing life under rugged conditions, you will want to learn how Johnson Bronze bearings can build more customer satisfaction into your product. If you need it, trained engineering help is available to guide you in choosing the bearings which will lower costs and improve performance. Johnson Bronze Company, 525 South Mill Street, New Castle, Pa.

Johnson Bearings

LEDALOYL (powder metallurgy) • BRONZE ON STEEL • ALUMINUM ON STEEL • CAST BRONZE • STEEL AND BABBITT

—ITEM 222—

For More Information Circle Item Number on Yellow Card—page 19

Withstands far greater

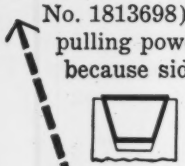
SHOCK LOADS

than any standard V-belt

Here are the interesting reasons why Gates Super Vulco Ropes stand up months, even years longer than *any* standard V-belts...

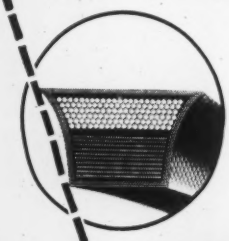
1. *Super-Strength Cords provide 40%* greater horsepower capacity . . . easily absorb heavy shock loads. **2.** *Flex-Weave Cover* (U.S. Pat. No. 2519590) provides greater flexibility with far less stress on the fabric. Cover wears longer — increases belt life, lowers belt costs.

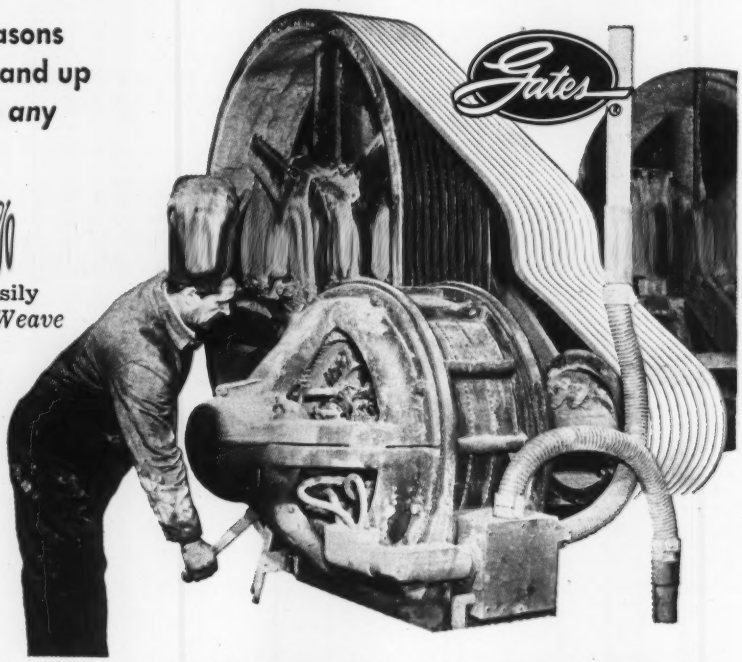
3. *Concave Sidewalls* (U.S. Pat. No. 1813698) provides sure pulling power, longer wear because sides straighten out as belt bends— make even contact with sheave walls.



Straight-sided belts bulge out when bent around sheave

Uneven contact causes uneven wear.





SHOCK LOAD of this big jaw crusher at Canadian Quarries, Ltd. is absorbed by Gates Super Vulco Rope Drive. Wherever shock load is severe, Gates Super Vulco Ropes cushion the shock—keep machinery replacement cost down.

3 other outstanding advantages

Resists Oil, Heat and Weather: Long life is assured even in the presence of excessive oil . . . even under prolonged exposure to heat and weather.

Provides Static Safety: The high electrical conductivity of Gates Super Vulco Rope provides safer drives in explosive atmosphere.

Saves Space: Higher horsepower rating and greater resiliency may permit fewer belts, or smaller sheaves where space saving is vitally important.

The Gates Rubber Co., Denver, Colorado
World's Largest Maker of V-Belts

Gates SUPER Vulco Rope

The V-Belt with 40% more horsepower capacity

TPA 57

—ITEM 223—
For More Information Circle Item Number on Yellow Card—page 19

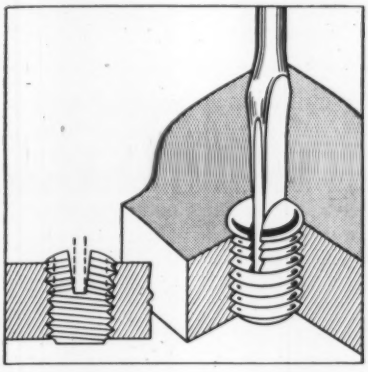
tive load. **National Pneumatic Co.**, Holtzer-Cabot Div., 125 Amory St., Boston 19, Mass.

—Circle ITEM 64

Self-Locking Setscrews

for use in soft metals

Headless, self-locking Spred-Lok setscrew is suitable for use in soft metals such as aluminum and certain grades of steel, particularly in applications subject to vibration. Top of the screw is spread slightly during manufacture permitting it to yield to the "flow" of soft metal and thereby effect a



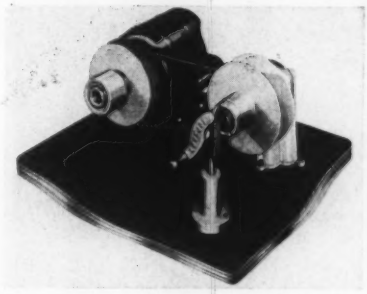
locking action. Screw is installed with a parallel-shanked screw driver so that engagement is at the bottom of the slot. Moving the driver from side to side to increase spread increases locking pressure. The screw can be removed and reused without appreciable loss in locking efficiency. **Set Screw & Mfg. Co.**, 28 Main St., Bartlett, Ill.

—Circle ITEM 65

Adjustable-Speed Pulley

for step-up and step-down service

Offered in 8:1 maximum ratio, adjustable-speed compound-drive pulley maintains constant belt alignment through its entire speed range. Driven speeds are 5550 to 690 rpm when pulley is used with a ¾-hp, 1750 rpm motor; with 1150 rpm motor, speed range is 3650 to 454 rpm at ½-hp. Accommodating NEMA motor frame shafts, pulley employs standard A-section belt and is available either spring-loaded or manually operated. Spring-loaded model is 6½ in. OD, 5 in. long; manual



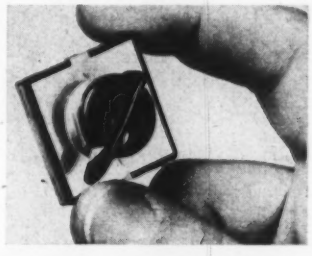
unit measures 6 in. OD by 3⅜ in. long. Oil-impregnated bearings and precision-ground sliding surfaces insure low maintenance. Pulley can be reverse mounted if necessary. **Lovejoy Flexible Coupling Co.**, 4818 W. Lake St., Chicago 44, Ill.

—Circle ITEM 66

Rotary Appliance Switch

simplifies wiring connections

Installation of this enclosed rotary appliance switch is simplified by a pressure-lock terminal which automatically clamps prepared ends of the conductors when they are inserted in the housing. Also available with solder lugs, the switch is approved by Underwriters' Laboratories at 125 v 6 amp, ac. Plastic snap-in handles in several colors, or metal shafts for user's handles are provided. Switch is made with either two, three, or four positions, with positive cam positioning by a detent action.



Case measures 1¼ x 1¼ x 27/64-in. **General Electric Co.**, Accessory Equipment Dept., Bridgeport 2, Conn.

—Circle ITEM 67

Nylon Cement

requires no curing

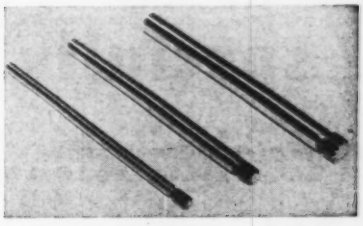
Adhesive bonds produced by Nylosil cement possess the inherent characteristics of nylon, are resistant to oils, aromatics, acids and alkalies, and are effective over wide temperature ranges. Produced in a range of viscosities, the cement requires no curing, and will fill gaps that result when the joined surfaces are imperfectly matched. Applications include all fabrication processes employing either flexible or rigid nylon. **Ions Exchange Corp.**, 44 Leonard St., N. Y. 13, N. Y.

—Circle ITEM 68

Pinion Shafts

are precision ground

Designated type F4, these precision ground pinion shafts may be used with stock units such as spur gears, slip clutches, and differentials. Pitches of 48, 64, 72, and 96 are standard, and number of teeth range from 10 to 18. Normal pressure angle is 20 deg; 14½ deg



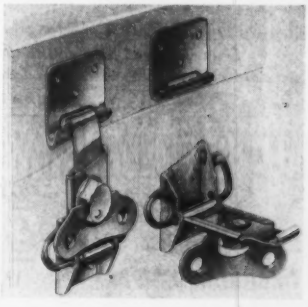
angle is available on request. Pinion shafts are held to ± 0.0001-in. tolerance in basic diameters of ⅛, 3/16, and ¼-in. **PIC Design Corp.**, 160 Atlantic Ave., Lynbrook, L. I., N. Y.

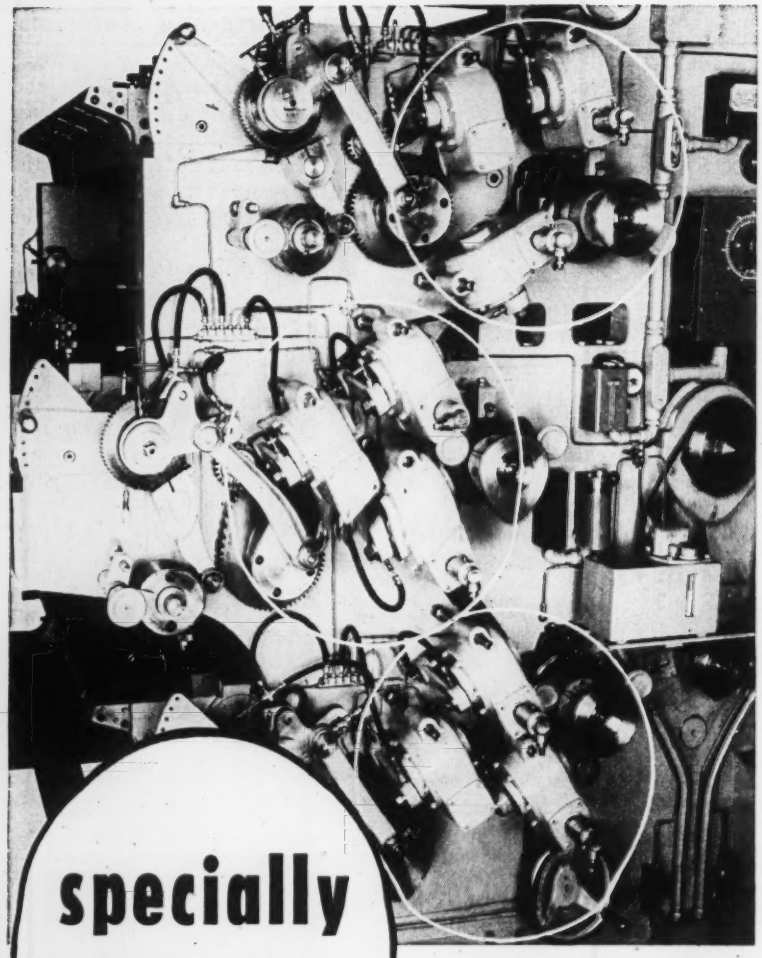
—Circle ITEM 69

Spring-Loaded Latch

compensates automatically for permanent gasket set

Spring action of positive-locking Link-Lock fastener provides automatic compensation for permanent gasket set or for irregularities in





specially designed...

This close up photo shows installation (circled) of OHIO Speed Reducers. Note the angle mounting of each reducer.

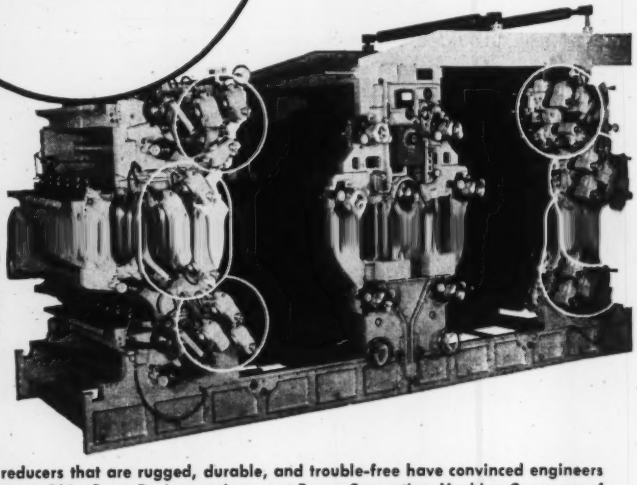


Illustration at the right pictures a complete unit and the location and operation of 18 OHIO Speed Reducers.

. . . speed reducers that are rugged, durable, and trouble-free have convinced engineers to depend upon Ohio Gear. Design engineers at Paper Converting Machine Company of Green Bay, Wisconsin worked with Ohio Gear in developing the special Speed Reducers for their new Multicolor Rotary Rubber Plate Letterpress. Special speed reducers are an all important factor in the operation of these 6 color presses where color control and accurate register are essential for process printing.

Ohio Gear can help you design a special reducer for your application where a standard unit will not do the job. Let us help you with your special gearing problems.

ESTABLISHED 1915

OHIO GEARS

OHIO GEAR COMPANY • 1338 East 179th Street • Cleveland 10, Ohio

—ITEM 224—

New Parts

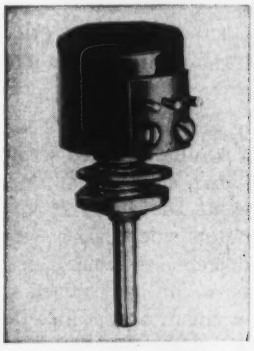
the sealing surface. Possibility of spring failure under heavy load is eliminated by the design, wherein loads greater than 75 per cent rated are carried by rigid members. Suitable for inexpensive container application, latch is available in either medium-duty or light-duty models, with capacities of 1000 and 300 lb, respectively. Impact and drop-test resistance is good, and the unit can be used in Arctic temperatures. **Simmons Fastener Corp.**, 1700 N. Broadway, Albany 1, N. Y.

—Circle ITEM 70

Miniature Potentiometer

withstands high temperatures

Designed for maximum continuous operating temperature of 300 F, this miniature RVG-10 potentiometer is 5/8-in. OD, weighs 3/8-oz, and maintains linearity and performance at high temperature and



vibration levels. Winding resistances from 20 to 30,000 ohms in single or multi-gang arrangements are available. Minimum resolution is 0.09 per cent, linearity is 0.25 per cent, and the unit conforms to MIL-E-5272A specifications. **Gamewell Co.**, Newton Upper Falls 64, Mass.

—Circle ITEM 71

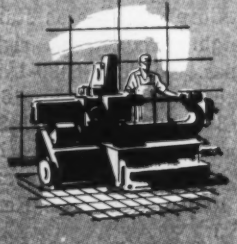
Welded Fastener

for rapid assembly in limited space

Fast assembly of a wide variety of metal products can be accomplished with PN nuts, which are resistance welded to product components. Long, narrow design permits use of these fasteners in channels, closely spaced holes, nar-

A complete line of Roller Bearings . . .

For every field of transportation and industry



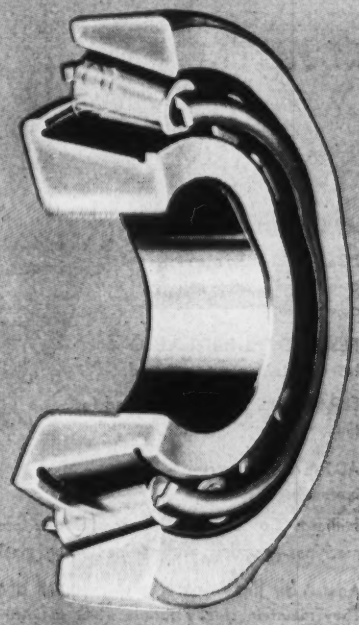
Job-tailored
in a wide range of sizes to fit your specific needs

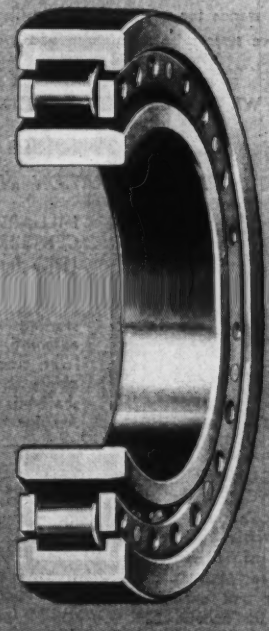
Aircraft? Automobiles? Earth-moving or farm equipment? *Whatever* you make, if your product uses straight or tapered roller bearings, Bower can meet your specifications *exactly*. For dependable Bower bearings are virtually custom-built to the job . . . engineered and sized to match any requirement.

Important, too, are exclusive Bower design features that assure long life, top performance, *less maintenance*. And when you specify Bower bearings you can always be certain of the highest quality materials and workmanship. These reasons, of course, are why Bower straight, tapered and journal roller bearings are used by leading manufacturers everywhere—for any application.

Let a Bower engineer give you full details of the complete Bower line.

Call him in while your product is still in the design stage.





SPHERO-HOWED

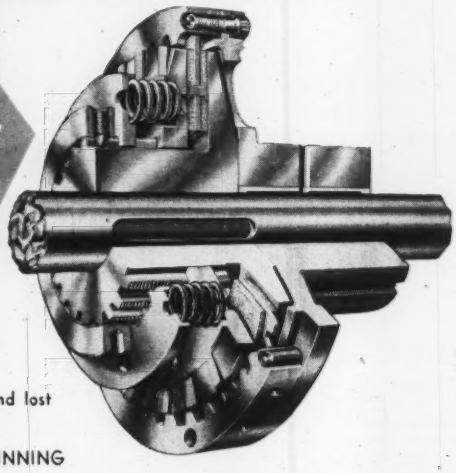
BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION • *FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICH.*

—ITEM 225—

HILLIARD *Clutches*
FOR POWER CONTROL DESIGN

ADJUSTABLE
Slip Clutch



- PROTECTS against overload, jams and down time.
- RESUMES THE DRIVE AUTOMATICALLY after overload.
- ELIMINATES SHEAR PINS and lost time.
- ADJUSTABLE - WHILE - RUNNING feature is available.

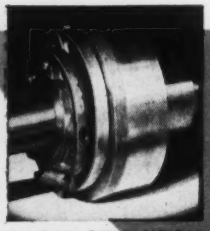
Hilliard Slip Clutches are continuously protecting the drive on dish washing machines—printing presses—packaging machines—case loaders—foundry equipment—air filters—conveyors—overhead doors—and many others.
They maintain steady torque while permitting speed variation on fabric drying drums, steel strip slitters and similar equipment.

The adjustable-while-running types are used to maintain constant tension on rewind stands for paper coaters, textile machines, rope, steel and wire mills and for drive systems requiring overload protection but which must be disconnected at times.

WRITE TODAY FOR BULLETIN 300 WITH COMPLETE INFORMATION.

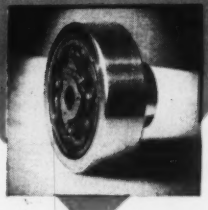
● OTHER HILLIARD CLUTCHES ●

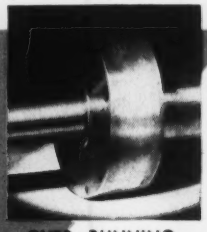
CONSIDER AUTOMATION - INVESTIGATE THESE PRODUCTS



SINGLE REVOLUTION CLUTCHES for automatic accurate control—electrical or mechanical—of intermittent motion, indexing, cycling and cut-off. Ask for Bulletin 239.

HILLIARD - TWIFLEX CENTRIFUGAL COUPLING for smooth, easy starting of any load automatically with overload protection and ability to accommodate shaft misalignment. Ask for Bulletin CE-3.





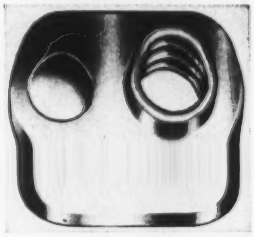
OVER-RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet, or backstop action. Ask for Bulletin 231.

THE HILLIARD *Corporation*
MANUFACTURING CLUTCHES FOR OVER 50 YEARS

103 WEST FOURTH ST., ELMIRA, N. Y.
IN CANADA: UPTON • BRADEEN • JAMES, LTD.

—ITEM 226—

New Parts



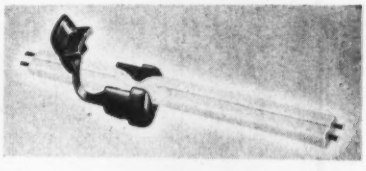
row flanges, confined corners, on tubing, and for multiple fastenings. Nut is made with a rounded, self-locating pilot to facilitate manual or automatic location in the hole provided for it. A projection on the bottom of the nut localizes current flow and heat during welding. The top of the threaded portion is countersunk to receive the screw. Seven sizes are available, with No. 6-32 to 3/8-16 threads. Dimensions range from 7/16 to 5/8-in. wide, 5/8 to 1 1/8-in. long and 3/32 to 5/32-in. thick. **Ohio Nut and Bolt Co.**, 33 First Ave., Berea, O.

—Circle ITEM 72

Strain Reliefs

for parallel, heavy-duty wires

Four new sizes of Heyco nylon strain reliefs grip wire firmly and anchor it to chassis or appliance at the point of entry. They insulate completely and absorb push, pull and torque. Developed for



the new SPT-3 parallel heavy-duty wire, units are available as standard straight-through or right-angle types. Model SR-30-1 accommodates wire sizes No. 16/3, 16/2, 18/3 and 18/2; model SR-33-1 accommodates wire sizes No. 14/3, 14/2, 16/3 and 16/2. **Heyman Mfg. Co.**, 100 Michigan Ave., Kenilworth, N. J.

—Circle ITEM 73

Check Valves

rated at 125 and 150 psi

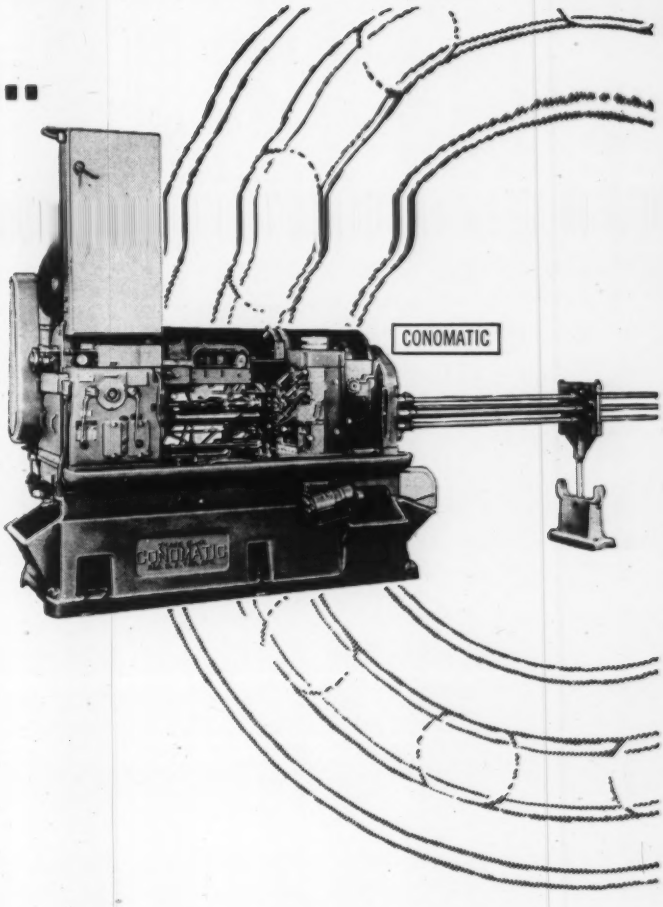
Line of Y-pattern swing check valves is available in both solder-end and threaded-end types, in 125

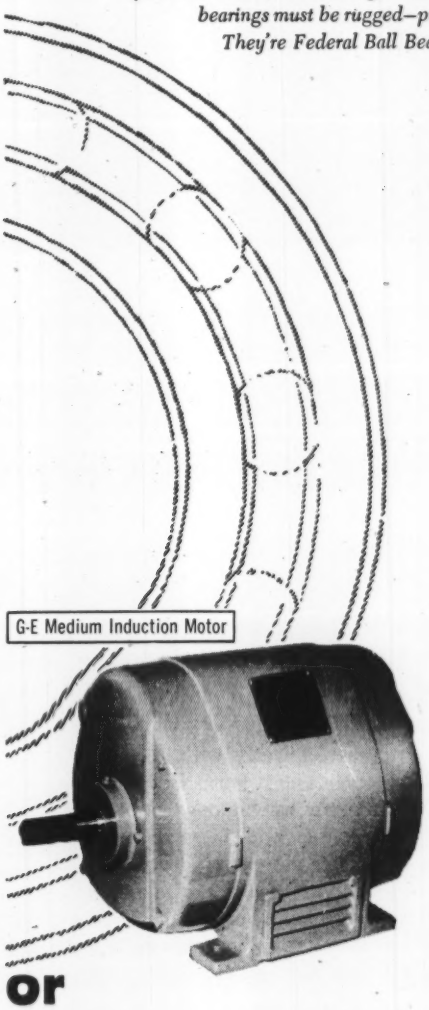
to feed a tool...

Automatic feed transmissions on newest type Conomatic Six Spindle Bar

Machines have to deliver a powerful,

steady tool drive under heavy loads for precision carbide machining. Feed shaft bearings must be rugged—precise. They're Federal Ball Bearings.





or

quiet a motor...

The smooth hum of today's precision-built motors whispers the efficiency of every part. Here, too, Federal Ball Bearings quietly perform their continuous, anti-friction assignment—whatever the size—whatever the type.

so much of industry *turns* on FEDERAL ball bearings

Machine tools—motors—or moving vans! At plant, home, machine shop! On the highway, on the farm—where there's anti-friction work to be done, you'll find Federal Ball Bearings quietly and efficiently on the job. Hundreds of types—12,000 sizes—produced by this 50-year-old manufacturer of ball bearings...exclusively.

When Federal Ball Bearings are a part of so many things you *use*, shouldn't they be a part of the things you *make*?

Just off the presses! *175 pages of ball bearing and engineering data* —FEDERAL'S NEW CATALOG! *Just drop us a line and we'll speed you your copy.*

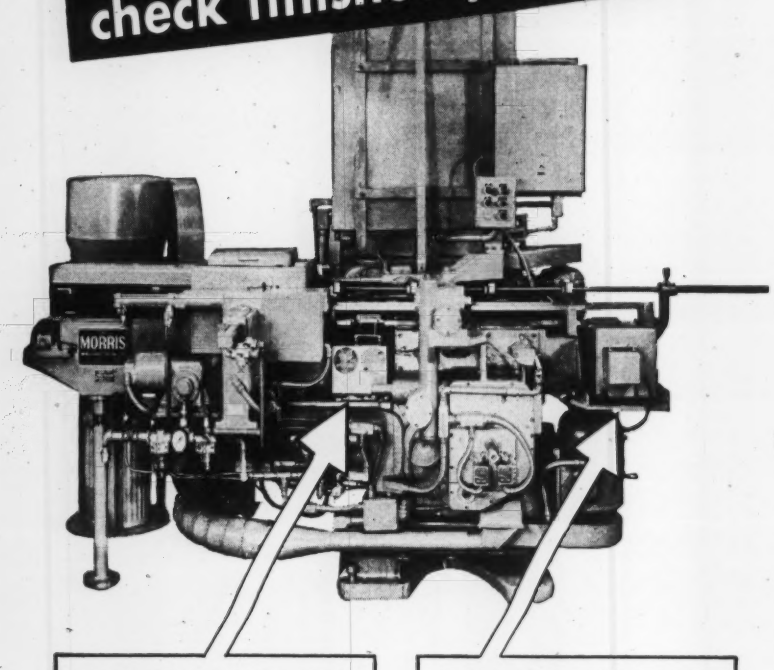
THE FEDERAL BEARINGS CO., INC. • POUGHKEEPSIE, N. Y.

Federal BALL BEARINGS

One of America's Largest Ball Bearing Manufacturers

—ITEM 227—

Built-in SCALES pre-set machine and check finished product



PRE-SET BY EXACT WEIGHT

In MORRIS PISTON MILLING MACHINE, scale No. 1 determines amount of overweight that must be removed to balance pistons. Linkage transfers reading to depth of cut and sets machine for milling off the correct amount of excess pad.

INSPECTED BY EXACT WEIGHT

After milling, piston travels to the second scale where it is checked against predetermined weight. The SHADOGRAPH scale is adjusted to one gram, plus or minus. Should final check show over or under this amount, machine is automatically stopped.

The above application shows how EXACT WEIGHT precision designed scales can be fitted into modern machine tooling to bring your operations a step nearer automation.

If you are now designing machines or products that require accurately controlled weight as a part of their manufacture, investigate our SHADOGRAPH Scale application. These scales can be easily built into most modern production machines. Their absolute accuracy adapts itself to complete electronic application and control.

Complete engineering data is available for designers. Write, giving your specific application.

Sales and Service Coast to Coast

There is no substitute for Exact Weight

Exact Weight Scales

Better quality control
Better cost control

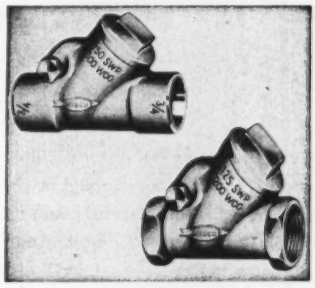
THE EXACT WEIGHT SCALE COMPANY

923 W. Fifth Avenue, Columbus 8, Ohio

In Canada: P.O. Box 179, Station S, Toronto 18, Ont.

—ITEM 228—

New Parts



and 150 psi working pressure ratings. Sizes range from ⅜ through 2 in. The valves for lower pressure are furnished with brass disks, and those for high pressure have composition steam disks. The Y-pattern design permits direct access to the flapper and disk assembly, permitting maintenance without removal of valves from the line. Design also provides instant, positive closure when flow is interrupted, in either vertical or horizontal position. **Northern Indiana Brass Co.**, Elkhart, Ind.

—Circle ITEM 74

Appliance Motor

24 per cent lighter than former models

Interchangeable electrically and mechanically with former designs, fractional horsepower motor for home appliances is 24 per cent lighter and is ventilated by five times more air. Formex wire and polyester film slot insulation provide high physical strength and extreme moisture resistance while guarding against winding burn out in resistance split-phase models. Lubrication system is factory sealed. Motor is available in 1/6, ⅓, and ¼-hp ratings, with or without base, and is suitable for

DU PONT ELASTOMERS

NEOPRENE – HYPALON

4 in Design

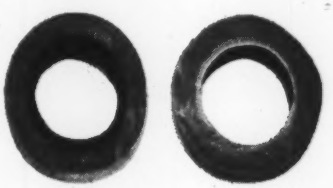
DU PONT HYPALON® extends the boundaries of design for elastomeric materials

Resilient Products made of HYPALON, for use under severe service conditions, offer you new materials for design. Among the many outstanding advantages of HYPALON is its resistance to oxidizing chemicals.

Here is a partial listing of chemicals which have little or no effect on HYPALON compositions:

Chemical	Concentration	Maximum Temperature
Chromic Acid	50%	200°F.
Nitric Acid	20%	158°F.
Phosphoric Acid	85%	200°F.
Sodium Hypochlorite	20%	200°F.
Sulfuric Acid	95.5%	70°F.
Pickling Solution (20% Nitric Acid, 4% Hydrofluoric Acid)		158°F.

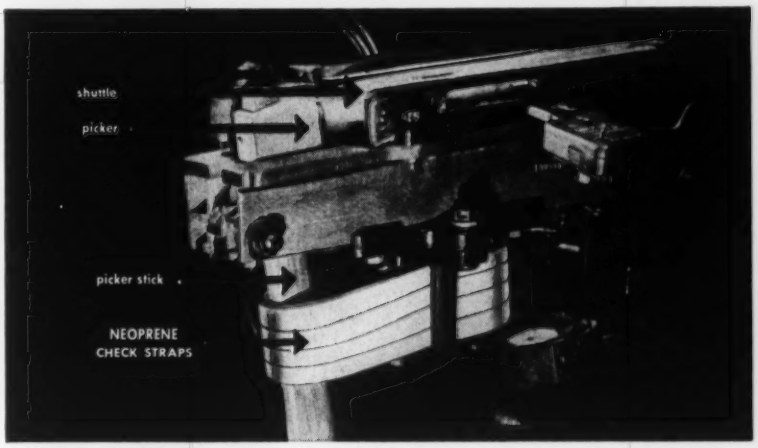
In addition to chemical resistance, HYPALON products are resistant to other severe conditions such as heat, ozone and weathering. HYPALON can be used in applications where temperatures range from 250°F. to 350°F. It is unaffected by ozone. It can be compounded in a complete range of lightfast, weather-resistant colors. So, when your designs anticipate severe service, consider HYPALON. Mail the coupon today for further information.



Natural Rubber HYPALON

Two tubing samples were filled with 98% (66°Be.) sulfuric acid for 24 hours at room temperature. Rubber deteriorated rapidly. HYPALON remained undamaged.

Newly designed NEOPRENE check straps outlast leather 3 to 1 on new high-speed textile looms



Neoprene's flex life, heat resistance reduce replacements, eliminate adjustments

A recent improvement in check-strap design promises to save the textile industry upwards of $3,000,000 annually. From the designer's viewpoint, this success is due to an imaginative approach—designing a three- or four-piece neoprene strap to replace a conventional one-piece leather strap.

This is the story. On high-speed looms the shuttle is hurled back and forth across the loom face at the rate of 200 times a minute. Every time the picker (see photo) throws or catches the shuttle, the picker stick slams into the check strap and stops. The combination of flexing, heat buildup and high weaving-room humidity made several adjustments of one-piece leather straps necessary to compensate for stretching, and limited their service life to 6 to 8 weeks. Many kinds of leather straps were tried, but leather still tended to distort, elongate, become fleshy and break.

The first and most important need was a check strap that wouldn't stretch. This was accomplished by plies of woven fabric and tire cord. But these strength-giving members had to be firmly bonded into a homogeneous strap in order to operate properly. Naturally neoprene was chosen as the best possible binder, because it had good adhesion to the fabric, was resilient and flex-resistant, and retained these properties in spite of heat and splash oil.

Performance confirms choice

And service confirmed the soundness of the manufacturer's choice of materials. The new straps lasted 3 times longer than the best leather, and stretch adjustments were completely eliminated.

You, too, can solve design problems by using neoprene products. For further information on designing new or improved products with neoprene, clip and mail the coupon below.

DU PONT
REG. U.S. PAT. OFF.

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Please send further literature and add my name to the mailing list for your free publications, the "Neoprene Notebook" and "Facts about HYPALON®," which show how the Du Pont elastomers are used in designing new products, improving old.

E. I. du Pont de Nemours & Co. (Inc.)
Elastomers Division, Dept. MD-2
Wilmington 98, Delaware

Name_____ **Position**_____

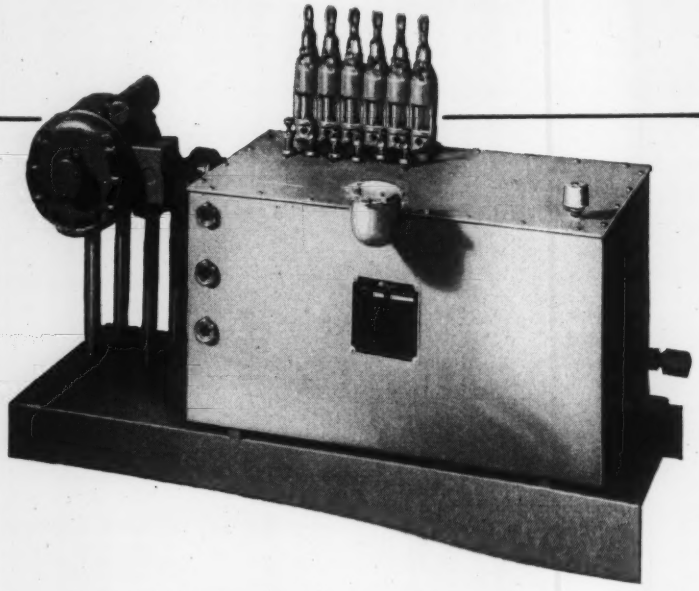
Firm_____

Address_____

City_____ **State**_____

MANZEL

Has a Long Record of Successfully Doing the "Impossible" in Lubrication



Manzel engineers repeatedly provide dependable, automatic lubrication where others said it couldn't be done.

Whether your requirements are in the "impossible" category — or as simple as they can be — ask Manzel to work with you in building dependable, automatic lubrication into the equipment you design.

Manzel Force Feed Lubricators

Deliver the exact amount of lubricant required, at precisely the right places, and at accurately-timed intervals. There are models to operate against pressures up to 30,000 psi. When it's a question of how best to lubricate, always call Manzel.

Special Quality Features of Manzel Lubricators

- Completely protected with Parco Lubrite
- Rust resistant reservoirs
- Closer fitting plungers made possible by special precision equipment
- Gears of harder alloy for longer wear
- Every unit factory tested before shipment

Manzel

Professionally qualified engineering representatives throughout the country.

DIVISION OF

HOUDAILLE INDUSTRIES INC.

276 BABCOCK ST., BUFFALO 10, N. Y.

—ITEM 230—

New Parts

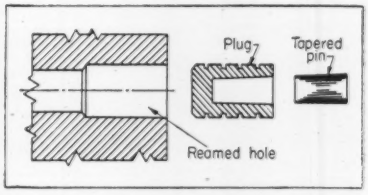
horizontal or vertical mounting. Stator and rotor parts can be provided for built-in applications. **General Electric Co.**, Schenectady 5, N. Y.

—Circle ITEM 75

Pin Plug

seals exterior holes

Designed to seal exterior holes that have been drilled during manufacture of pneumatic and hydraulic equipment, this pin plug has a tapered, reamed hole which is expanded by a driven tapered pin.



When ends of the pin and plug are flush, an interference fit of 0.002-in. results in the passage hole, effectively preventing fluid leakage. Grooves on the outside diameter of the plug act as seals and retaining rings. Plugs are available for drilled holes from ⅛ to ½-in. diam. **Lee Co.**, Westbrook, Conn.

—Circle ITEM 76

Indicator Lights

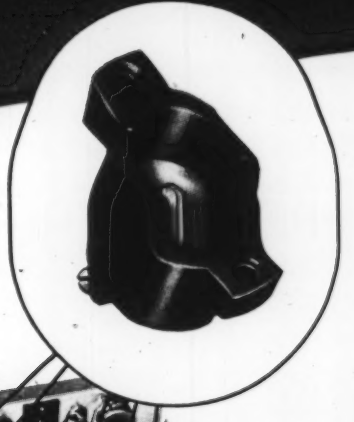
subminiature type with maximum visibility

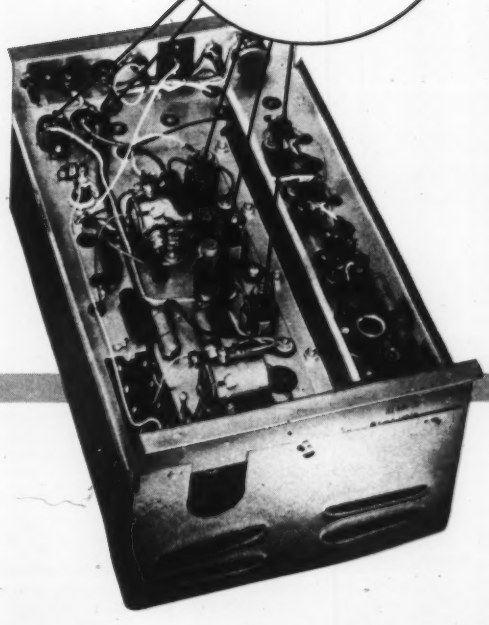
Two-terminal indicator or warning lights employ miniature AN-3140 lamps mounted deep inside a long plastic lens. Inside bevelling of the lens distributes the light throughout the entire periphery, providing maximum visibility from all angles. The heavy lens is over 13/32-in. long to permit use of the lights with either standard or edge-lit panels. Series L-6600

Apelco USES KLIXON

Circuit Breakers

For Dependability Under the Most Rugged Conditions





The new, powerful AE-156-CM Marine Radiotelephone manufactured by Applied Electronics Company, Inc., San Francisco, California, incorporates every element essential to dependable local and long distance radiotelephone performance.

To insure the best in protection of power supply circuits, Apelco uses Klixon Circuit Breakers. Here's what Mr. S. S. Konigsberg, President, writes:

"You will note that there are five Klixon Circuit Breakers in use in the power supply. As the power supply is the source of current to motivate the radiotelephone, you can see how important it is to use reliable components. It must be able to perform at all times and under the most rugged circumstances.

"Apelco has found that Klixon Circuit Breakers go on the job and keep on with the least possible attention. As we make over fifty different power supplies for the extensive line of radiotelephones we manufacture, you may see what an important part they are of our program."

What's your control problem . . . circuit protection, low or high temperature limitation, fuel delay, tube and rectifier cooling, fan or burner operation . . . Klixon Circuit Breakers and Thermo-Snap® Controls are successfully meeting hundreds of requirements for a variety of such applications in military and civilian equipment, daily.

Klixon Circuit Breakers and Thermo-Snap Controls are available in hermetically sealed and open types with fixed temperature settings to meet your needs.

Our Field Engineers will gladly help you work out application details . . . no obligation, of course.

KLIXON

Trade mark reg. U. S. Pat. Off.

METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
3202 FOREST STREET, ATTLEBORO, MASS.

—ITEM 231—

GEAR PROBLEMS?

—Check with

FAIRFIELD!

IF you use gears in the product you make, we believe it will pay you, as it has others, to become acquainted with FAIRFIELD—the place where fine gears are produced to meet your specifications EFFICIENTLY, ECONOMICALLY! Fairfield's production facilities are unexcelled for making all kinds of accurate, automotive type gears such as are now finding wide use in all branches of industry: for Tractors, Trucks, and Buses . . . for Agricultural Implements . . . for Machine Tools. Ask for latest literature describing Fairfield's facilities. *Your inquiry will receive prompt attention.*

Fine Gears Made to Order

SPUR GEARS—Straight, helical, and internal. Sizes from 16 pitch, 1½" dia., to 1½ pitch, 36" dia.

HERRINGBONE—(*Fellows Type*). Sizes from 1½" to 15".

SPIRAL BEVEL—Sizes from 16 pitch, 1½" dia., to 1½ pitch, 28" dia.

STRAIGHT BEVEL—Sizes from 16 pitch, 1½" dia., to 1½ pitch, 28" dia.

HYPOID—Sizes from 1½" to 28" dia.

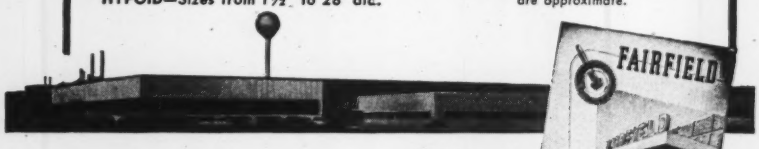
ZEROL—Sizes from 16 pitch, 1½" dia., to 1½ pitch, 21" dia.

WORMS AND WORM GEARS—Worms to 7" dia. Worm gears to 36" dia.

SPLINED SHAFTS—Lengths to 52". Diameters from 1" to 6".

DIFFERENTIALS—10,000 to 300,000 inch pounds capacity.

Note: All of the sizes above are approximate.



Ask for interesting, illustrated bulletin.

FAIRFIELD MANUFACTURING CO.

2307 South Concord Road • Lafayette, Indiana

New Parts

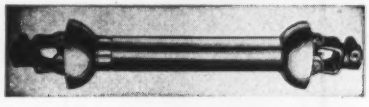
measures 1 15/64 in. long by 15/32-in. diam; series L-3200 is 1 9/32-in. long by ½-in. diam. The lamp circuit is fully insulated from the case in both types, and the series L-3200 light has a built-in test circuit. **Hetherington Inc.**, Sharon Hill, Pa.

—Circle ITEM 77

Shielded Driveshafts

offer safety and ease of servicing

Removable, integral safety shield for nonslip plain or slip assemblies rotates freely on this jointed driveshaft. Assembly or disassembly of the shield from the shaft is accomplished quickly for servicing. Design incorporates full ball-bearing construction at each end of the



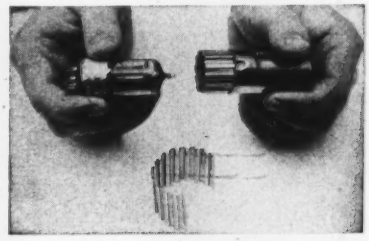
shaft, with the balls in a special cage for servicing. Axial movement allows them to pass over the end of the hub and drop into the machined race for assembly. Races are induction-hardened and are protected against dust by a sealing ring held in place by three sheared tongs in the shield bell. One-piece tube and shield bell is constructed of heavy-wall tubing. **Rockwell Spring and Axle Co.**, Blood Brothers Machine Div., Allegan, Mich.

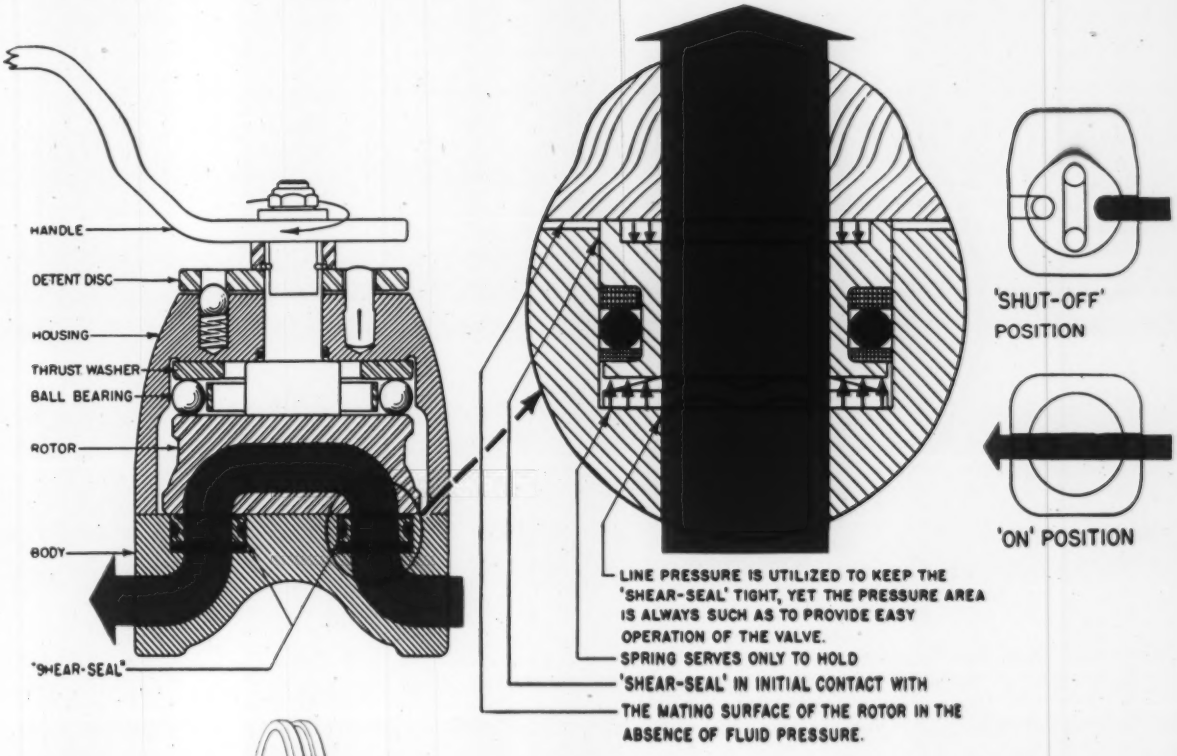
—Circle ITEM 78

Tube Cooling Insert

reduces tube failures

When used with a miniature tube and JAN shield, this insert reduces bulb temperatures approximately 120 C from those obtained when the JAN shield is used alone. Corrugations of the black matte-finish cylinder contact both tube and




HANDLE
DETENT DISC
HOUSING
THRUST WASHER
BALL BEARING
ROTOR
BODY
"SHEAR-SEAL"
'SHUT-OFF' POSITION
'ON' POSITION
LINE PRESSURE IS UTILIZED TO KEEP THE 'SHEAR-SEAL' TIGHT, YET THE PRESSURE AREA IS ALWAYS SUCH AS TO PROVIDE EASY OPERATION OF THE VALVE.
SPRING SERVES ONLY TO HOLD 'SHEAR-SEAL' IN INITIAL CONTACT WITH THE MATING SURFACE OF THE ROTOR IN THE ABSENCE OF FLUID PRESSURE.

THE "SHEAR-SEAL" VALVE PRINCIPLE IS WELL WORTH YOUR STUDY

Cost and hydraulic control of many products have been improved through the incorporation of "Shear Seal" valves. Manual or Solenoid shut-off and selector valves will handle air, oil, water, grease, fuel and gas at pressures ranging from vacuum to 6000 PSI.

The patented "Shear-Seal" principle consists primarily of a pressure balanced, self-aligning, tubular valve seat, the "Shear-Seal," constantly in perfect contact with an optically flat porting disc, or rotor. The porting disc, or rotor, contains flow passages which are oriented by rotation of the rotor. Mating surfaces of the "Shear-Seals" and rotor are lapped to a five micro inch finish and are checked with monochromatic light waves to assure optical flatness within one light band per inch.

Rugged marcel compression springs maintain intimate contact at all times between the self-aligning "Shear-Seal" and the optically flat rotor. Positive leakproof closure is accomplished by means of this marcel spring, plus a predetermined hydraulic force on the "Shear-Seal." Thus, the higher the pressure, the tighter the seal. This controlled hydraulic load on the "Shear-Seal," in conjunction with large ball thrust bearings, is responsible for the exceptionally low handle load encountered with "Shear-Seal" valves, even at 6000 PSI operating pressures.

Actuation of a Barksdale Valve shears the fluid flow, (hence the name "Shear-Seal") and the square external corner of the "Shear-Seal" face wipes the rotor clean. Thus the sealing surfaces stay clean. Continuous intimate contact of "Shear-Seal" and rotor prevents dirt or foreign particles from entering between sealing surfaces. Dirt might otherwise hold the valve open, as with a poppet, or cause scored sealing surfaces and severe leakage, as with a conventional spool or slide valve.

Fluid flow always takes place through the opening in the center of the "Shear-Seal" rather than across sealing surfaces, (as occurs with a conventional poppet or needle valve). Sealing surfaces of the "Shear-Seal" and rotor are further protected by constant contact with each other. As a result, erosion or "wire drawing" are not experienced with "Shear-Seal" valves, even with extremely dirty, high velocity fluid.

Severe service over a period of years clearly shows that "Shear-Seal" valves improve with use because of the self-alignment and the self-lapping, wear compensating characteristics of the "Shear-Seal." Barksdale Valves actually "wear-in" where others "wear-out."

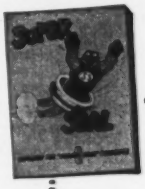
Long life and low maintenance cost have created wide acceptance in the field—indisputable proof of the soundness of the Barksdale "Shear-Seal" principle.

For the more complete story, visually explained in comic book sequence, write for "Super Seal explains the Shear-Seal principles." Included are some interesting cut-out models which further demonstrate the unusual characteristics of this valve principle.

BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

Send FREE bulletin "Super Seal Explains the 'Shear-Seal' Principle."



NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

—ITEM 233—

Cramer

RUNNING TIME METERS

Type 631E

widest time ranges . . variety of models

The Cramer line of running time meters and time totalizers offers a complete selection for measuring and accumulating time intervals, from the hundredth part of a second to hours.

A variety of types—reset or non-reset . . . meter mounted or portable . . . drum or dial counters—are available to meet your exact requirements, and all are driven by the precision-built, high torque Cramer synchronous motor.

Whether used for research, preventive maintenance, or recording operating characteristics of a machine or system, you'll find a Cramer time totalizer ideal for the job.

Write for Bulletin PB-610.

Type 640B
Portable reset type

Type 690
Precision totalizer

Type 630E
Flush panel mounted

Type 640E
Fully enclosed, with reset wheel

Cramer TIMING DEVICES

SPECIALISTS IN TIME CONTROL

The R. W. CRAMER CO., Inc.

BOX 6, CENTERBROOK, CONNECTICUT

ICR56B

New Parts

shield intimately, allowing heat to flow through the shield into the chassis. According to the Navy Electronics Laboratory, where the insert was developed, this heat transfer reduces tube temperatures well below allowable values. The insert is available in sizes to fit all types 5½ and 6½ miniature envelopes. **Birtcher Corp.**, 4371 Valley Blvd., Los Angeles 32, Calif.

—Circle ITEM 79

Molded Parts

of fluorocarbon resin

Molded pipe elbow and bellows, made from chemically inert fluorocarbon resins, are designed for applications involving acids and caustics, foods and drugs, hot lacquers, steam, synthetic oils, jet fuels and

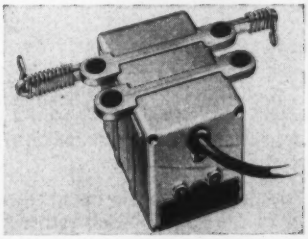
gases, and vapors under extreme temperature conditions. Fluoroflex-T pipe elbow is available in both 45 and 90-deg types for use with Fluoroflex-T laminated pipe or any ASA flanged piping. Molded bellows and expansion joint is available in 1, 1½, 2 and 3-in. diameters. Special designs and shapes can be made. **Resistoflex Corp.**, 39 Plansoen St., Belleville, N. J.

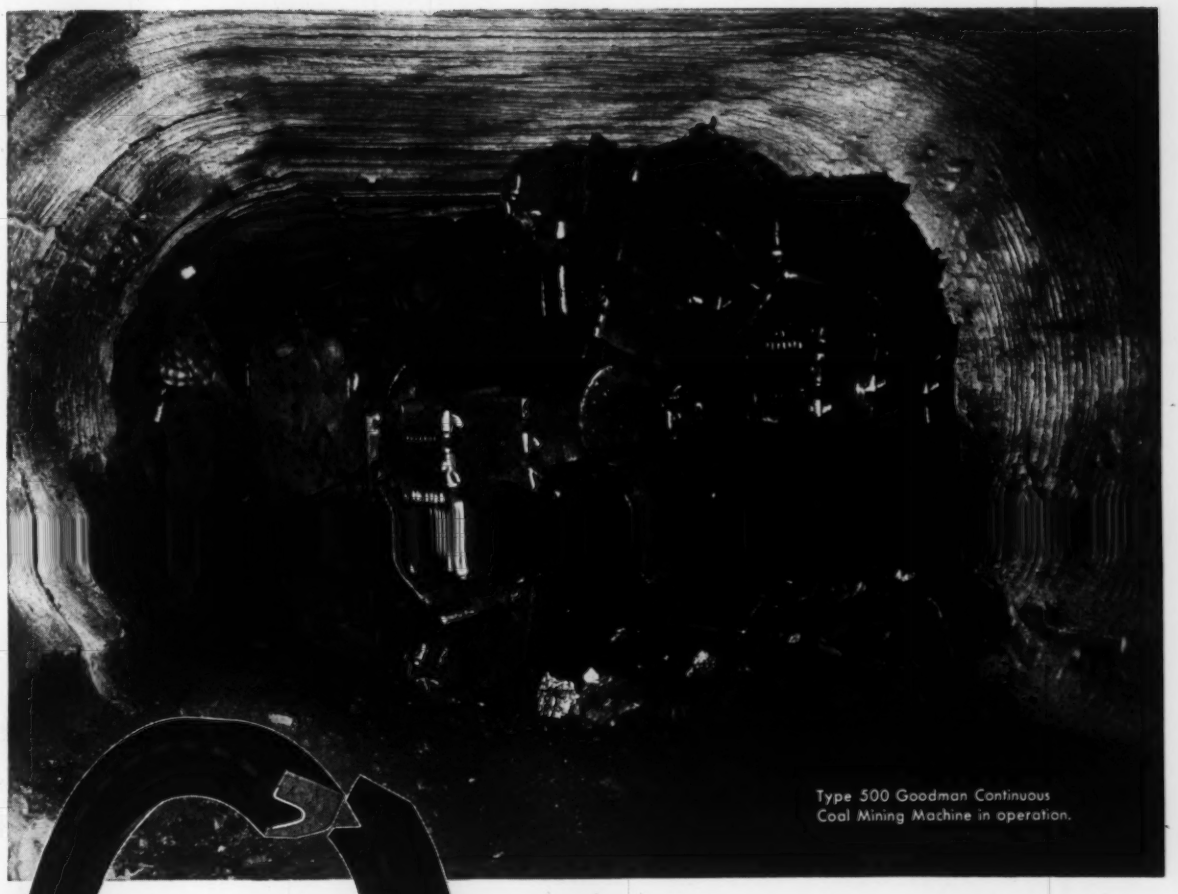
—Circle ITEM 80

Induction Motor

has positive two-way action

In model 311-R safe-return motor, power from a pair of high-speed induction motors is converted by





Type 500 Goodman Continuous Coal Mining Machine in operation.

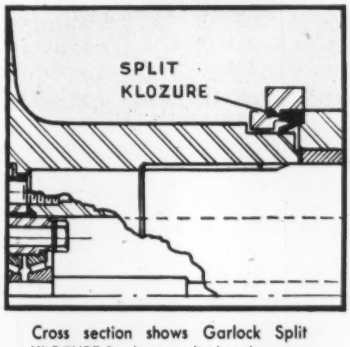
Garlock Split-KLOZURE Oil Seal—specifically designed for heavy equipment.

Goodman Mining Machines get positive bearing protection with KLOZURE* OIL SEALS!

The bearings on Goodman Mining Machines are subjected to the most severe service conditions—particularly coal dust and dampness. To provide positive protection for these costly bearings, Goodman engineers use dependable KLOZURE Oil Seals.

Garlock Split-KLOZURES, which can be installed around the shaft *without* dismantling the equipment, are used on the main bearing. Standard Model 53 Finger Spring KLOZURES (not illustrated) are used on the tractor roller bearings.

Let us show you how superior KLOZURE Oil Seals can solve your sealing problems. Just contact the Garlock office nearest you, or write for KLOZURE Catalog 10.



Cross section shows Garlock Split KLOZURE Seal as applied to the rotor assembly (main) bearing of Goodman's Type 401 Miner.

*Registered Trademark

THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK

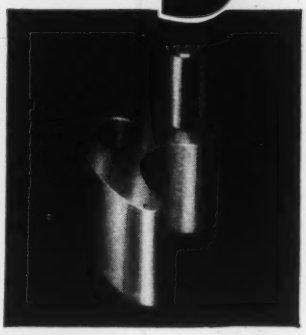
Sales Offices and Warehouses: Baltimore, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, Los Angeles, New Orleans, New York City, Palmyra (N.Y.), Philadelphia, Pittsburgh, Portland (Oregon), Salt Lake City, San Francisco, St. Louis, Seattle, Spokane, Tulsa.

In Canada: The Garlock Packing Company of Canada Ltd., Toronto, Ont.

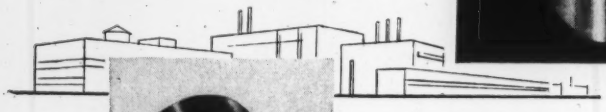
GARLOCK

ANNOUNCING

...SINTERED POWDERED METAL BEARINGS and PARTS by Bunting!®



The newest facilities for the production of bearings and parts made of Sintered Powdered Metal are now offered to designer, engineer and machinery manufacturer by The Bunting Brass and Bronze Company.



Bunting resources, reputation and responsibility together with a complete new plant and modern equipment provide Sintered Powdered Metal products at a high point of quality and precision.

Bunting Engineering is available without cost or obligation to all who wish to use or explore the cost advantages that this versatile product brings to the mechanical industries.

Sintered Plain and Flange Bearings, Solid and Tubular Bars and Thrust Bearings are available from stock in a wide range of sizes. Quotations for special bearings or special parts will be sent promptly on receipt of prints.

Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

—ITEM 236—

New Parts

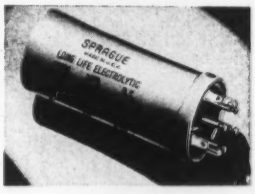
rack and pinion to straight-line strokes in either direction. Direct lift of the arm is 25 lb over a distance of 4 in. in 30 seconds; maximum throw is approximately 12 in. When the motor is used to operate heavy mechanical equipment, either automatically or by remote control, it can stall indefinitely without damage. Power for the unit can be specified as 25, 50 or 60 cycles per second at 20 v or higher. **Gleason-Avery Inc.**, Auburn 1, N. Y.

—Circle ITEM 81

Electrolytic Capacitor

has extended life

Design of type 17D extended-life electrolytic capacitor incorporates high-purity materials to provide long operating life over a wide range of temperatures. Turret terminal and mounting lugs are



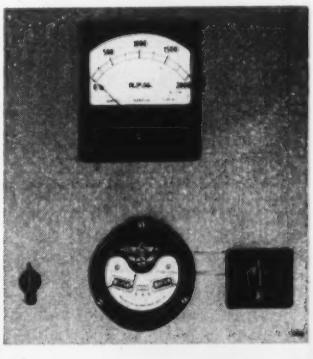
molded into the cover, which is crimped on a gasket to the aluminum can. Single, dual, and triple-section units are available in 19 standard ratings. **Sprague Electric Co.**, 167 Marshall St., North Adams, Mass.

—Circle ITEM 82

Speed-Change Senser

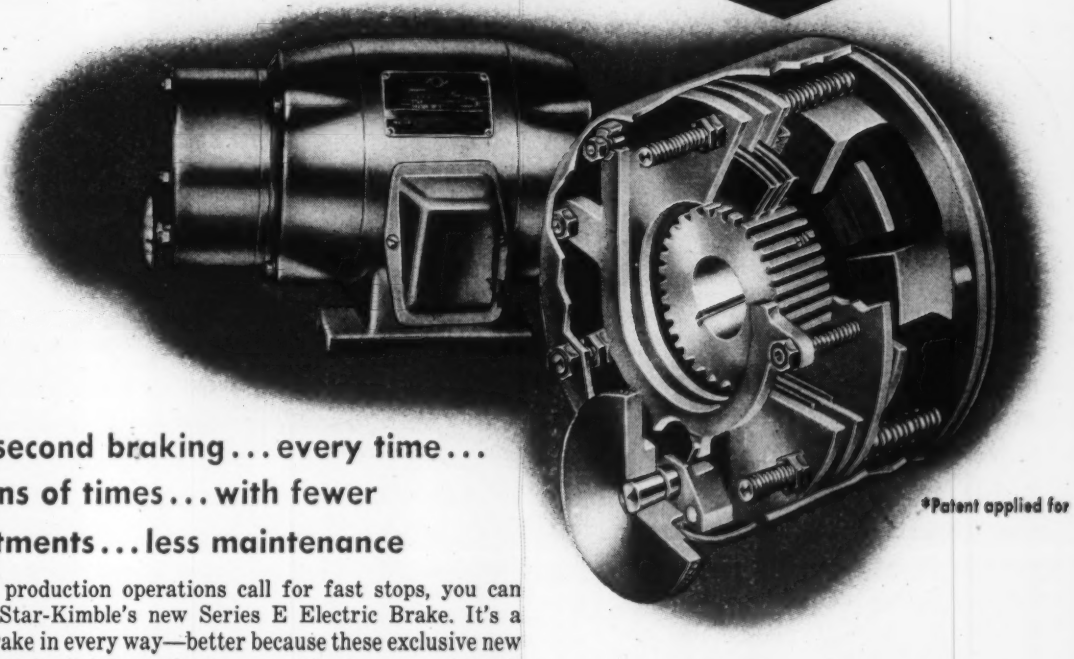
for speeds to 80,000 rpm

For use in precision automatic speed control equipment, this speed-change sensing system is accurate and flexible. It incorporates the Weston frequency responsive



Problem: to stop a load faster than you can say "STOP!"

Solution: the new STAR-KIMBLE SERIES "E" BRAKE*



*Patent applied for

Split-second braking... every time... millions of times... with fewer adjustments... less maintenance

When production operations call for fast stops, you can rely on Star-Kimble's new Series E Electric Brake. It's a *better* brake in every way—better because these exclusive new features make it inherently stronger, simpler, more dependable than conventional magnetic disk brakes:

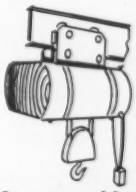
- Studs supported at both ends for better shock load protection
- Low-loss magnet cuts power losses up to 80%
- Six coil construction makes unit easily adaptable to all voltage supplies
- Low rate springs permit efficient operation at large air gaps
- Expendable friction disks deliver millions of smooth, positive stops, can be replaced in minutes when finally worn out
- Compact—more braking power in less space

Fits "C" Face brackets from 182 to 445 frames

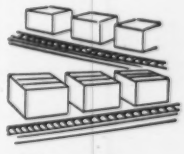
The new Star-Kimble Series E Brake fits any "C" face mounting, and shaft can be extended through cover for double-end operation. Brake is available in many torque ratings, either separately or as a completely integrated Star-Kimble Brakemotor. **Write for Technical Bulletin C-11**

In these exacting applications...

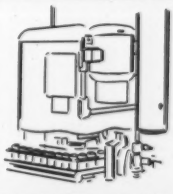
and many others, the Series E Brake or S-K Brakemotors insure dependable operation, minimum downtime for maintenance



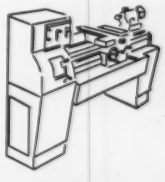
Cranes and hoists



Conveyor



Can closing machines



Lathe

Star-Kimble, for nearly half a century specialists in electric motive power for industry, is fully staffed to help original equipment manufacturers solve any design or production problems in this field. Star-Kimble designs and builds special motors, generators, and complete power packages, including controls.

STAR-KIMBLE
MOTOR DIVISION

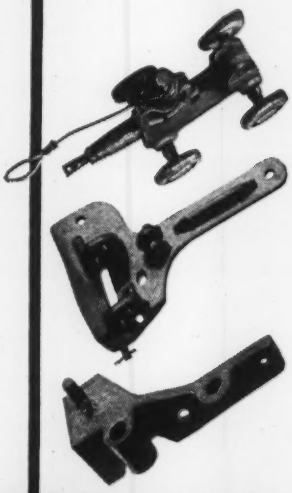
—ITEM 237—

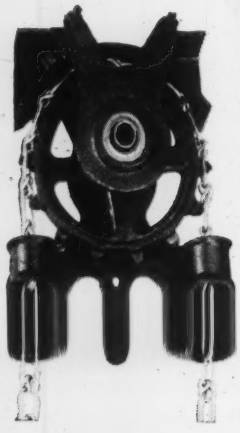
How About Malleable?

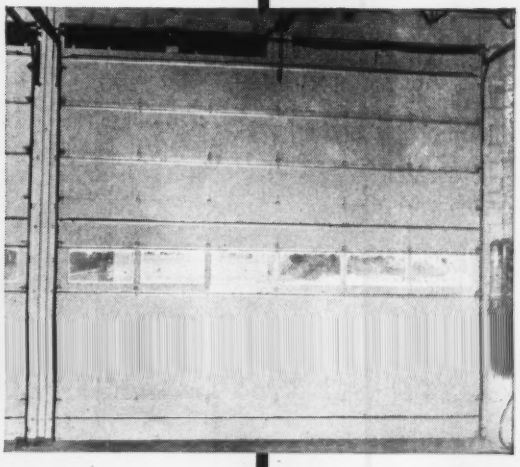
"Sturdiness and permanence pay," says a leading overhead door manufacturer.

Here is another manufacturer using malleable iron castings to improve his product. Malleable is noted for its tough strength, wear resistance, and ability to be produced in intricate shapes close to final form. Its excellent machinability, where machining is required, means trouble-free and low-cost finishing.

This versatile material has been utilized for 130 years in a wide range of applications and in every industrial field.







Call a malleable foundry and review your products with their engineers. They can often give you valuable suggestions. Or write to the Malleable Founders' Society.

Parts photos by courtesy of Quincy Mfg. Co., Tiffin, Ohio

1800 Union Commerce Building **Cleveland 14, Ohio**

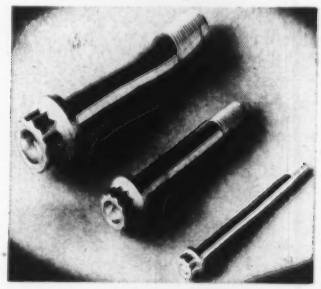
New Parts

system and will react to a speed change as small as 0.25-per cent of its maximum operating speed of 80,000 rpm. While the system operates automatically, it also incorporates a tachometer indicator to provide continuous speed indication. **Weston Electrical Instrument Corp.**, 614 Frelinghuysen Ave., Newark 5, N. J.

—Circle ITEM 83

Steel Bolts

have tensile strength of 180,000 to 200,000 psi



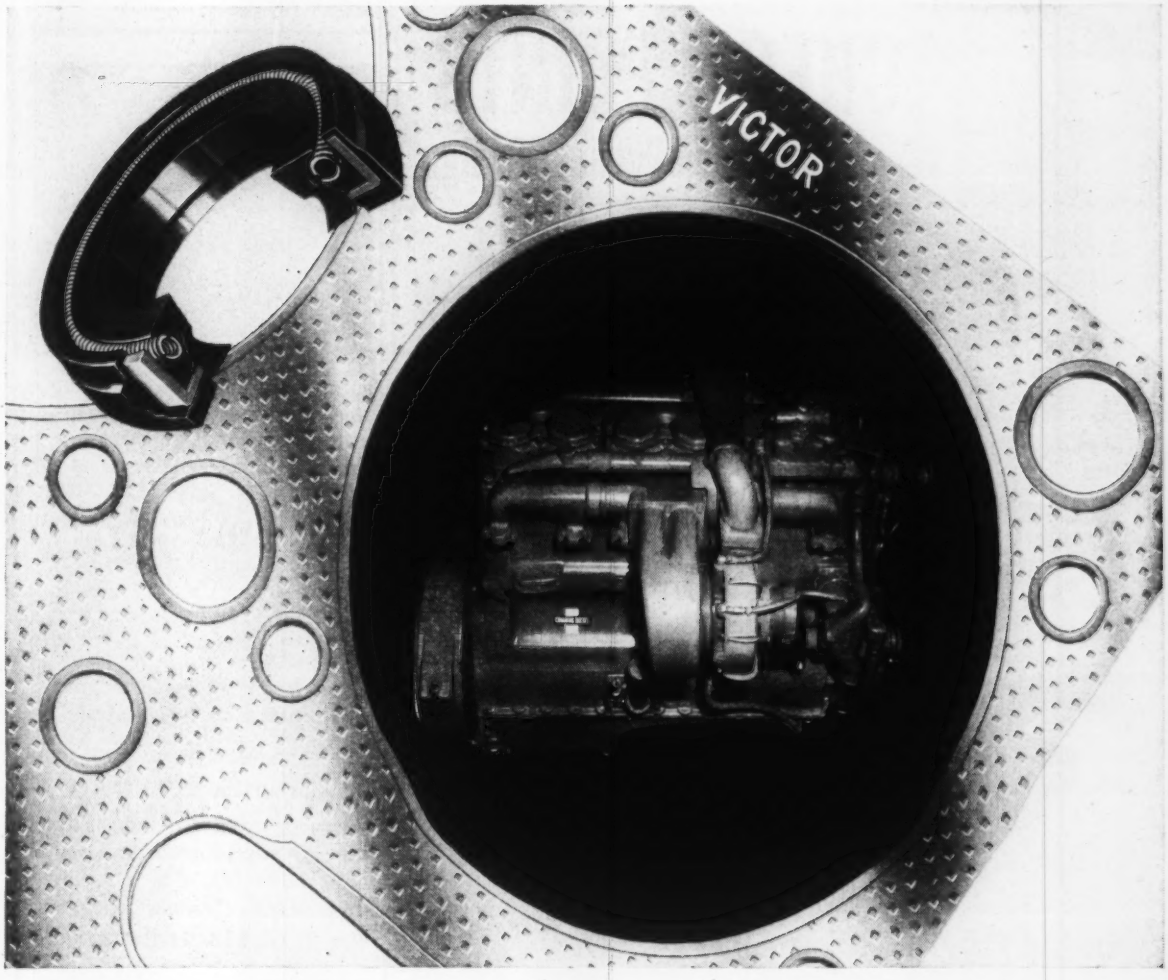
Aircraft type, 12-point external wrenching tension bolts have tensile strength ranging from 180,000 to 200,000 psi. Manufacturing techniques of forming bolt threads in one pass and controlled forging of the head provide the bolts with high resistance to dynamic fatigue or shock loading. Bolt's endurance limit—the maximum load that can be sustained repeatedly without failure—ranges from 50,000 to 60,000 psi. Designated EWB-18, the bolts are presently available in standard diameters ranging from ¼ to 1½ in. They are made from 4340 and 8740 alloy steels and are cadmium plated by the fluoborate method. **Standard Pressed Steel Co.**, Jenkintown, Pa.

—Circle ITEM 84

Rotary Air Motor

17-lb unit generates 2 hp

Weighing 17 lb, model 6AM rotary air motor develops 2 hp at 2000 rpm and 90 psi line pressure. The motor gives adjustable-speed power with a valve control. Four rotary vanes are centrifugally sealed against the housing and take up their own wear. Speed range is from 0 to 2000 rpm on air pres-



Long life of CUMMINS *TURBODIESELS* assured with VICTOR sealing

Quality Sealing Products for Every Vital Point

- VICTOPAC PACKING
- VICTOR HEAD GASKETS
- VICTOLEX PACKING
- VICTOPRENE OIL SEALS
- VICTORITE PACKING
- VICTOR MANIFOLD GASKETS

By matching power to job requirements, Cummins Turbodiesels deliver long-life, low-cost performance. And Cummins' designers see to it that maximum horsepower output is maintained.

With quality sealing components they prevent fuel waste and compression loss, and leakage of lubricant and coolant. They know that quality in these parts—gaskets, oil seals and packings—makes a powerful difference in engine performance.

Victor sealing is quality sealing for all types of heavy-duty power units. Victor's continuing research and development of materials and structures assure the ultimate design for each sealing need. Each Victor packing, for example, is classified and defined for service by SAE-ASTM specification.

In addition to sealing skill since 1909, Victor offers unmatched facilities for quality mass production. Let's get our engineers together.

Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill. In Canada: Victor Mfg. & Gasket Co. of Canada Limited, St. Thomas, Ont.

VICTOR

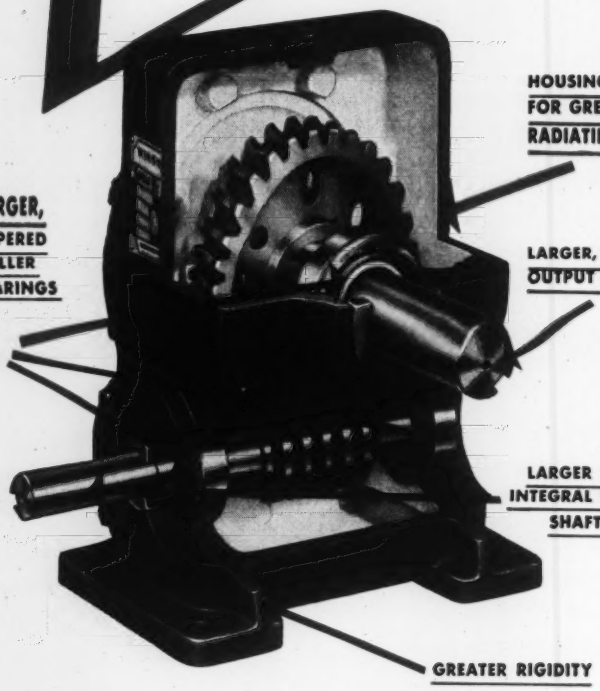
Sealing Products *EXCLUSIVELY*

GASKETS • OIL SEALS • PACKINGS

—ITEM 239—

For More Information Circle Item Number on Yellow Card—page 19

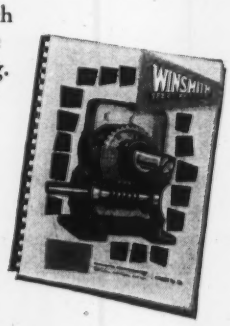
7 CHECK POINTS of Speed Reducer Design


HOUSING DESIGNED FOR GREATER HEAT RADIATING CAPACITY
LARGER, TAPERED ROLLER BEARINGS
LARGER, STRONGER OUTPUT SHAFTS
LARGER STRONGER, INTEGRAL WORM SHAFTS
GREATER RIGIDITY

...on the New "C" WINSMITH C SERIES

THESE 5 IMPROVED FEATURES of Winsmith's new "C" Series reducers mean greater performance, greater stamina, greater dependability...*greater value for your horsepower dollar.*

In all, 108 models comprised of single and double reduction units are available in the "C" Series...a unit to answer every speed reducer need. Compare our *increased* rated horsepower and torque output with reducers of competitive makes. For complete data on the "C" Series, write for catalog.



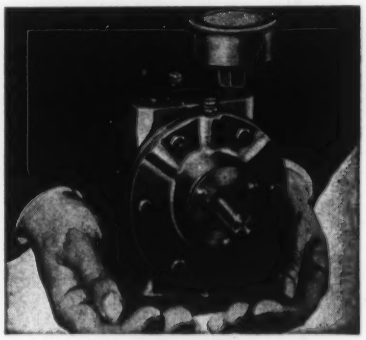
WINSMITH SPEED REDUCERS

NEW CATALOG! Describes the complete "C" Series plus other units in the Winsmith line. Contains drawings, dimensions, weights and ratings for each model described. Write today for Catalog No. 155—on company letterhead, please.

WINSMITH, INC. 16 Elton St., Springville, (Erie County), N. Y.

—ITEM 240—

New Parts



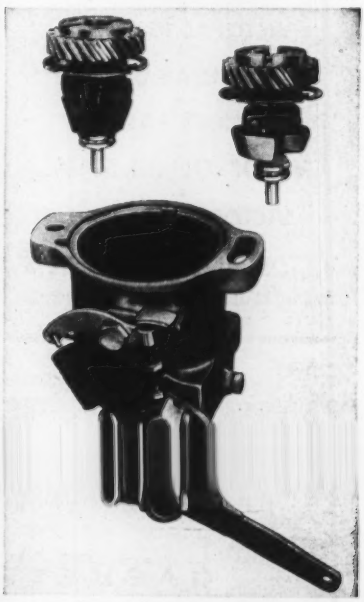
sures from 30 to 90 psi. Counter-clockwise rotation (shaft toward viewer) is standard; clockwise rotation is also available. **Gast Mfg. Corp.**, P. O. Box 117N, Benton Harbor, Mich.

—Circle ITEM 85

Speed Governor

has interchangeable weights for coarse or fine control

Interchangeability of two weight systems in the body of the 300-series governor permits satisfaction of regulation standards and cost requirements in a variety of applications. Cam-nose weight system in GC-5300 series provides 5 to 10 per cent speed regulation; GC-3300 series has laminated weights for 3 per cent or better regulation where close speed control is necessary. For close governing at only one speed, constant-speed model is recommended; long-range model offers regulation throughout a wide range of speeds. Control levers are reversible for right or left mounting, and a



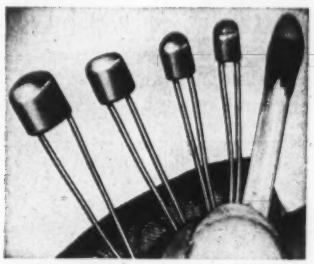
simple idling lever system is available for installations requiring idling control by a secondary device. **Pierce Governor Co. Inc.,** Anderson, Ind.

—Circle ITEM 86

Selenium Diodes

for input ranging from 156 to 203 v rms

Three subminiature selenium diodes provide bias for tubes in electronic equipment that must withstand severe environmental



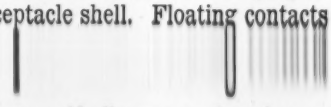
conditions. Type 6U1 is rated for a maximum input of 156 v rms; type 7U1, for 182 v rms; and type 8U1, for 203 v rms at 1.5 ma. These diodes are designed for stable operation in an ambient temperature range of −50 to 100 C. They are provided with pigtail leads to facilitate wiring into crowded chassis. **International Rectifier Corp.,** 1521 E. Grand Ave., El Segundo, Calif.

—Circle ITEM 87

Subminiature Connectors

with three, four or five contacts

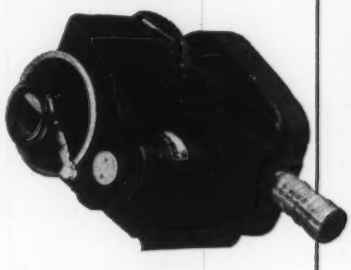
Subminiature connectors in the AN type 1300 series are available with three, four or five contacts. They are made with one-piece molded inserts to prevent moisture traps and electrical breakdowns. Precision-machined aluminum shells are finished to meet military requirements for salt-spray resistance, and the inserts are permanently swaged into the shell to form a single cartridge type unit. Inserts are interchangeable in the plug or receptacle shell. Floating contacts



assure self-alignment of each contact and minimize engagement and disengagement forces. Brass pin contacts and spring temper phos-

To label and package drugs for safe, effective use . . .

SHARP & DOHME needs good packaging machinery . . .



and this is the camera that helps them design it

It's the camera that has helped John Deere build a better beet harvester, Firestone make a safer tire, A. B. Dick meet a tight production schedule, Friden figure faster, Michigan Tool roll and sell a better spline.

The Kodak High Speed Camera does this by taking up to 3200 pictures a second on 16mm movie film. Projecting the film at normal speed slows down parts moving too fast for human eyes to follow—slows the action down as much as 200 times to a highly detailed crawl on the screen. The cause of trouble and often the cure stick out like a sore thumb.

Can the Kodak High Speed Camera solve problems for you? Find out by sending for a copy of the booklet, "High Speed Motion Picture Making in Industry."

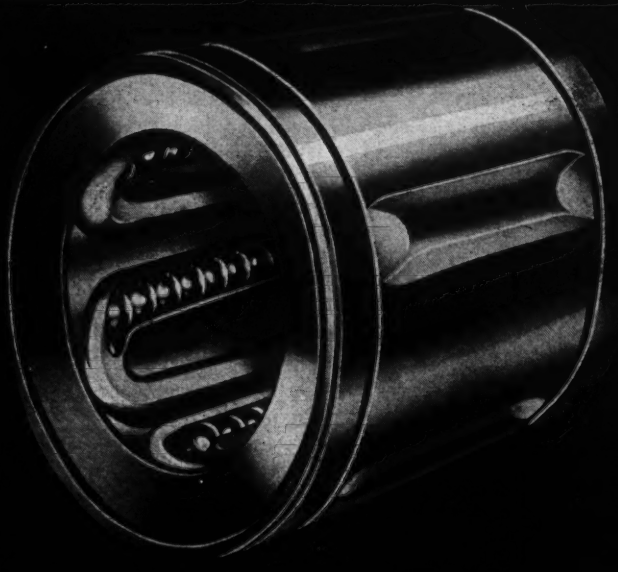
EASTMAN KODAK COMPANY
Rochester 4, N. Y.

the Kodak *HIGH SPEED* Camera

Kodak

—ITEM 241—

BALL BUSHING



The BALL BEARING for your

LINEAR MOTIONS

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers have solved this problem by application of the Precision Series A or Low-Cost Series B BALL BUSHINGS.

Alert designers can now make tremendous improvements in their products by using BALL BUSHINGS on guide rods, reciprocating shafts, push-pull actions, or for support of any mechanism that is moved or shifted in a straight line.

Improve your product. Up-date your design and performance with BALL BUSHINGS!

Now manufactured for ¼", ½", ¾", 1", 1½", 2", 2½", and 3" shaft diameters.

LOW FRICTION • LOW MAINTENANCE
ELIMINATES BINDING AND CHATTER
SOLVES SLIDING LUBRICATION PROBLEMS
LONG LIFE • LASTING ALIGNMENT

Progressive Manufacturers Use Ball Bushings
—A Major Improvement at a Minor Cost

THOMSON INDUSTRIES, Inc.

Dept. E, MANHASSET, NEW YORK

Write for descriptive literature and the name of our representative in your city.

Also manufacturers of NYLINED Bearings — DuPont NYLON within a metal sleeve—for rotation and reciprocation.

—ITEM 242—

New Parts

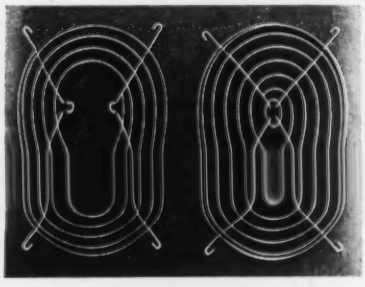
phor bronze contacts are gold plated. **DeJur Amsco Corp.**, Electronic Sales Div., 45-01 Northern Blvd., Long Island City 1, N. Y.

—Circle ITEM 88

Spiral Motor Mount

absorbs vibration and reduces motor noise

Adaptable to industrial and domestic motor applications, spiral wire motor mount absorbs vibrations and quiets motor operation.



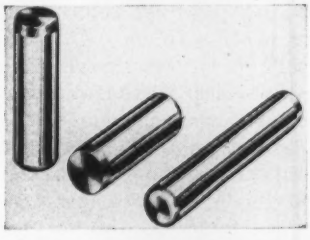
Combination guard and mount assemblies are available in platings and finishes to meet installation requirements. **E. H. Titchener & Co.**, 67 Clinton St., Binghamton, N. Y.

—Circle ITEM 89

Dowel Pins

ground for regular or oversize service

Surface hardened and ground to 0.0001-in. tolerance, these dowel pins are available in a full range of sizes from ⅛-in. diam by ⅜-in. long to 1 in. diam by 6 in. long.



Standard pins are 0.0002-in. larger than listed diameter for regular use, and 0.001-in. larger than listed diameter for oversize applications. **Bristol Co.**, Socket Screw Div., Waterbury 20, Conn.

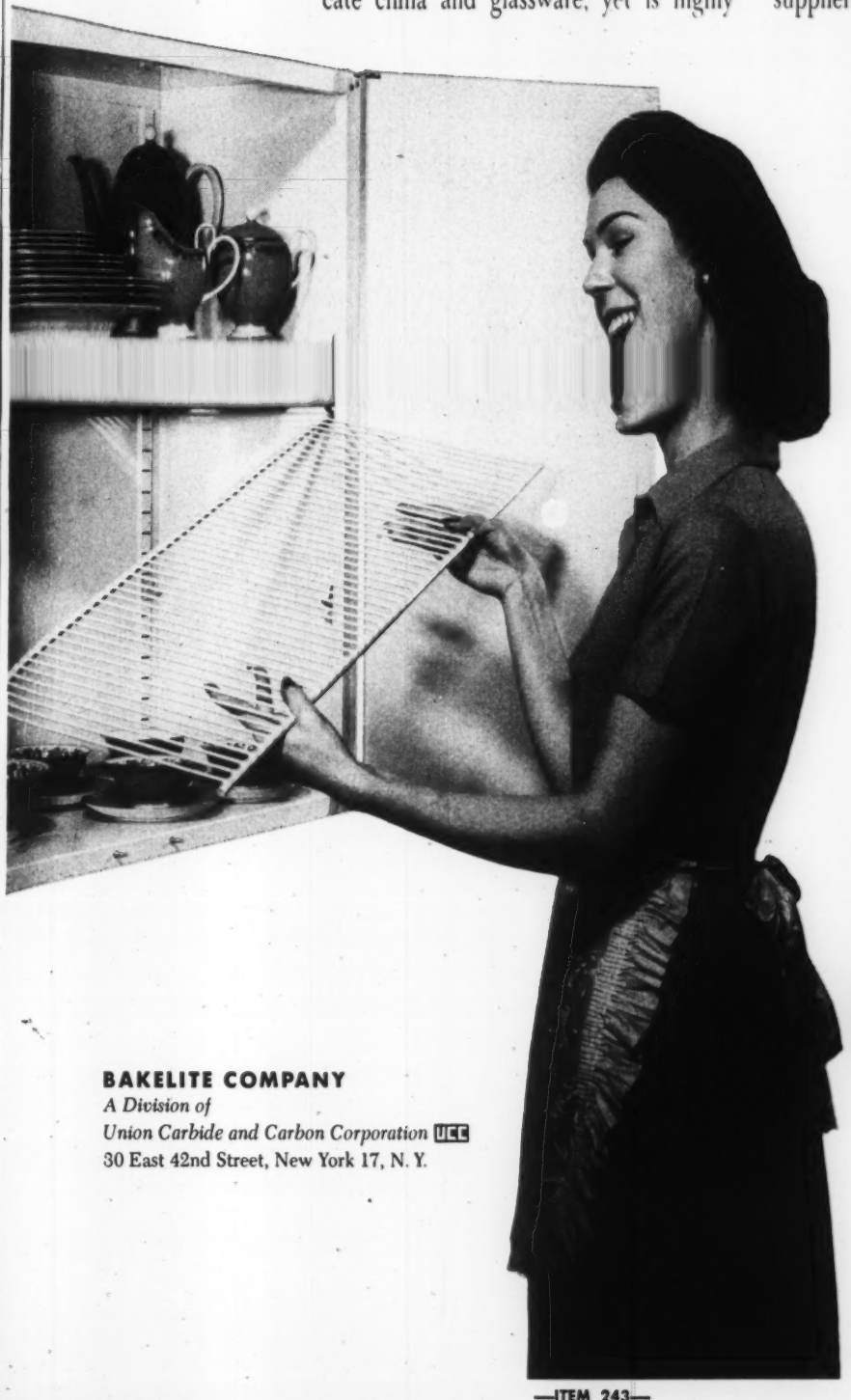
—Circle ITEM 90

"coated...to quiet the clatter"

That's why Geneva Modern Kitchens, Geneva, Illinois, coat kitchen cabinet shelves with plastisols based on BAKELITE Brand Vinyl Dispersion Resins.

"The 'whisper quiet' shelves have a smooth, shiny surface that will not attract dirt, is easy to clean, and has a rich warm feel," says R. W. Sponholtz, Vice President. "The coating provides a cushion for delicate china and glassware, yet is highly resistant to abrasion, corrosion by moisture, food and beverages. These features add much to the quality of our line."

Does your product require a coating that resists abrasion yet is soft and resilient? Or must it resist sun, chemicals, corrosion, flexing? The answer may be plastisols based on BAKELITE Brand Vinyl Dispersion Resins. For more specific information and a list of suppliers, write today to Dept. NC-103.



This shelf was dip-coated, followed by a short bake at moderate temperatures. Slush molding or injection molding with little or no pressure are other methods of using plastisols. Almost any color can be obtained and finishes can be glossy or matte. Coating for this Geneva Modern Kitchen shelf formulated by **Michigan Chrome and Chemical Co.**, Detroit, Mich.

BAKELITE COMPANY
A Division of
Union Carbide and Carbon Corporation UCC
30 East 42nd Street, New York 17, N. Y.

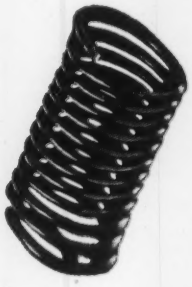
BAKELITE BRAND RESINS

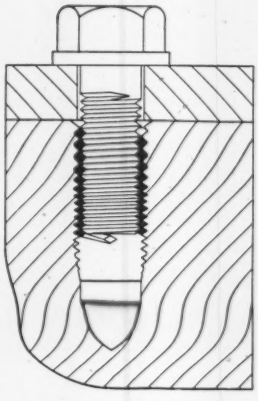
The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC

STRONGER CLEANER LIFETIME THREADS

in lighter, softer, thinner materials

with HELI-COIL* Screw Thread Inserts





Heli-Coil Inserts, coils of stainless steel or phosphor bronze wire, produce superior internal threads that solve many design problems. Thousands of manufacturers are using them to greatly increase thread strength in light metals, wood, plastics; to stop corrosion, seizing and galling; and to increase thread life. In thousands of applications *Heli-Coil* Inserts now enable designers to use thinner materials, shorter thread engagements, lighter materials—to save space, time and money.

Send in the coupon today. You'll get samples and complete information.

***Heli-Coil* Inserts conform to official Military Standards MS122116-122275(ASG), MS124651-124850(ASG) & MS33537(ASG)**

*Reg. U. S. Pat. Off.

HELI-COIL CORPORATION
122 Shelter Rock Lane, Danbury, Conn.

- ☐ Send samples and Design Manual 652A.
- ☐ Send samples and Military Standards Manual 689A.
- ☐ Please have a *Heli-Coil* Thread Engineer call.

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____ 3052

—ITEM 244—
For More Information Circle Item Number on Yellow Card—page 19

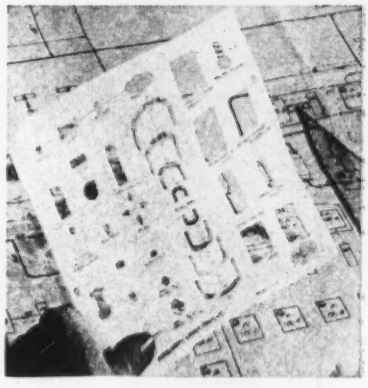
ENGINEERING DEPARTMENT

EQUIPMENT

Layout Template

aids in preparing graphic panels

Designed to reduce the time required for preparing graphic panel layouts, the Panelgraph layout template has outlines scaled at 2 in. to the foot, representing the



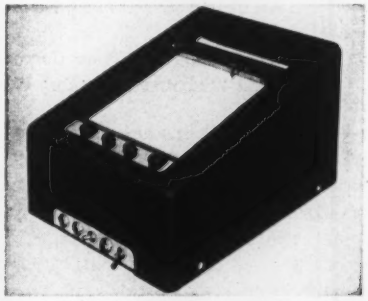
most frequently used industrial instruments. Also provided are outlines for pumps, valves and other graphic panel symbols, as well as vessels. Template is fabricated from 20-gage frosted Lucite. **Panelitt Inc.**, 7401 N. Hamlin Ave., Skokie, Ill.

—Circle ITEM 91

Flat Bed X-Y Recorder

available in 11 scale ranges

Flat bed of this recorder provides visibility of the plot during the entire plotting operation. The pen assembly adjusts to accommodate a full pad of plot paper, from which individual pages are easily



Fluid Feed AIR-HYDRAULIC DRILL PRESS FEED!

with Predictable Speed Control!

EXCLUSIVE NEW OIL-FLOW PRINCIPLE ADJUSTS RATE OF FEED ACCURATELY FROM 2 INCHES TO 60 INCHES PER MINUTE... Combines

Even Steady Hydraulic Feed with Economical, Dependable Air Power!

Learn how Mead's exclusive new oil-flow principle provides pre-selection of feed speed accurately from 2 to 60 inches per minute yet is adjustable during operation — how the usual needle valve and air bubble troubles are eliminated—how steady, even hydraulic control combines with economical, dependable air power to give faster, easier, better production.

See it working at BOOTH 215 ASTE INDUSTRIAL EXPOSITION Chicago, March 19-23

Write Now!

It will pay you to write factory or nearest Mead Representative (listed in Thomas' Register) for special 4-page folder plus Catalog of other Mead units suitable for automation with this remarkable new Fluid Feed Air-Hydraulic Drill Press Feed! Write now!

PATHFINDER IN AIR POWER AUTOMATION

MEAD

—ITEM 245—

designers! WHICH CHAIN TO USE?

CABLE or ROLLER?

Cable chains are used for special purpose applications where roller chains are not required. They are suitable for any kind of tension linkage applications such as counterweight mechanisms, elevator doors, lift trucks, pipe wrenches, etc. Cable chains give a greater ultimate strength for a given chain weight, size, and cost than any other type of chain.

ACME's chain engineers can advise you of the correct chain selection, that may save you both dollars and time. For any task involving chain, don't hesitate to get the free assistance of ACME chain engineers.

76 pages of illustrated data.

FREE CHAIN TEXT!

ACME's catalog is filled with chain facts, valuable data and tables that enlighten and save you time. Full table of sizes, strengths and list prices of cable and roller chain included. FREE upon request to engineers and designers. Write ACME CHAIN CORP., Dept.6-C Holyoke, Massachusetts.

ACME chains and sprockets are of unexcelled quality . . . available from distributors all over the U.S.A. and Canada. Contact yours, or write directly to us.

Call Holyoke JE 2-9458.

Acme Chain Corporation
HOLYOKE
MASSACHUSETTS

—ITEM 246—

Engineering Equipment

removed. Pen speed is ½-second full scale. Circuits employed eliminate 60 and 120-cycle pickup. This small, lightweight instrument is available in 11 scale ranges, from 5 mv to 500 v full scale. Input impedance is 200,000 ohms per volt. **Electro Instruments Inc.**, 3794 Rosecrans, San Diego 10, Calif.

—Circle ITEM 92

Negative Developer

can be used in normal office light

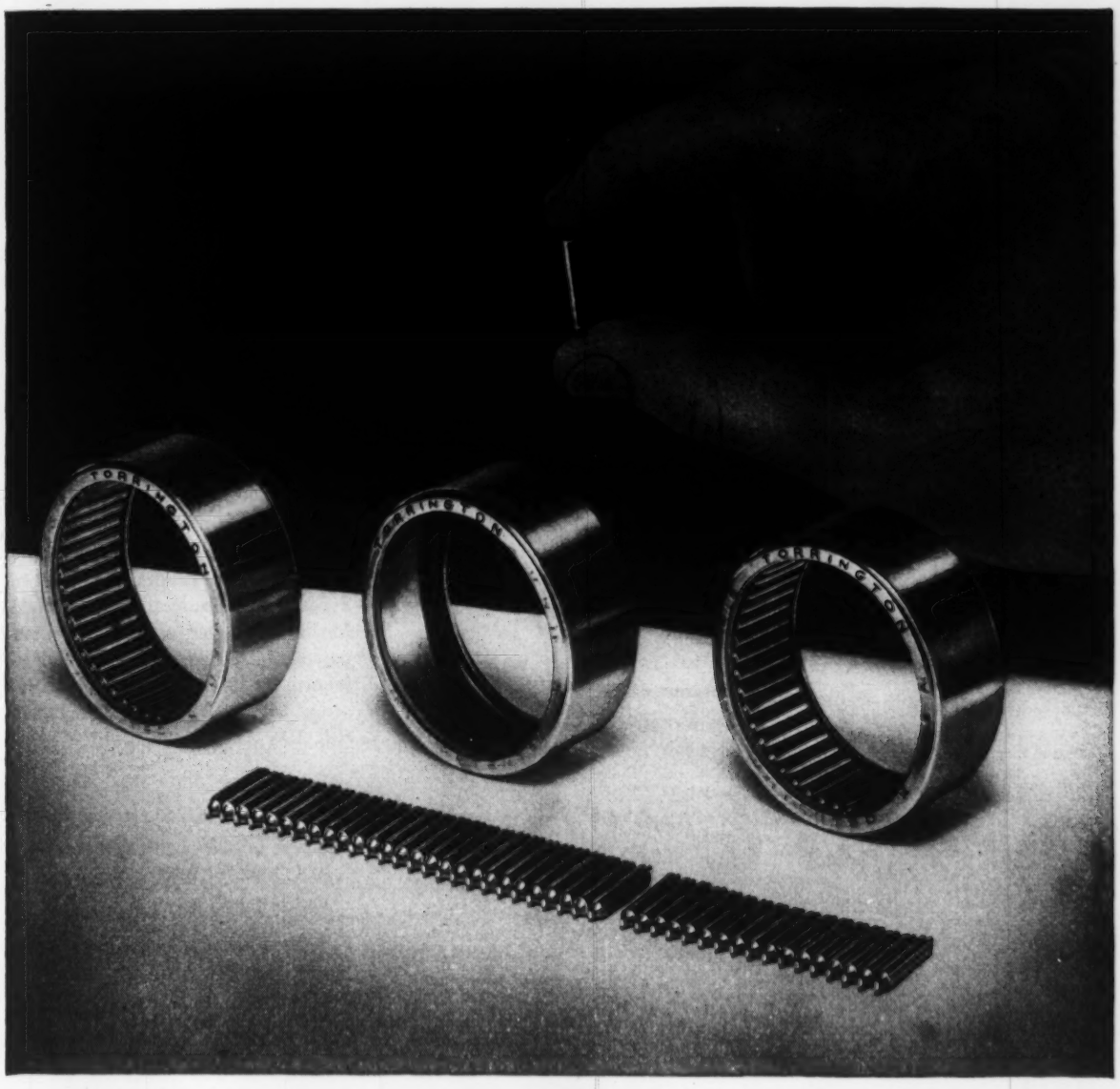
Model 356 Heccokwik developing unit, usable with any contact printer, is compact and self-contained. It is not restricted to use in a darkroom. The 20-lb developer is made of stainless steel, has permanently affixed guides, and turns off automatically when the cover is lifted. Cover lifts from one side to expose rollers and a prepositioned tray. It operates on 110-v, 60-cycle ac. **Hunter Photo Copyist Inc.**, 595 Spencer St., Syracuse, N. Y.

—Circle ITEM 93

Strain Gage Indicator

has eight input channels

Dynamic strain gage indicator with a large-screen display oscilloscope and eight input channels provides continuous display of eight independent channels of strain gage output information plus calibration data for each channel. All channels are scanned each ½-second. The oscilloscope contains a 17-in. rectangular cathode ray tube, below which are mounted a control panel, gage balance and calibration panel containing the eight independent channels, a sequential switching panel and a gage excitation power supply. Displacement, velocity, accel-



Here's where the **TORRINGTON NEEDLE BEARING** *gets its precision*

This Needle Roller is the "work horse" of the Torrington Needle Bearing. Its jewel-like precision is the key to smooth performance of the Needle Bearing. That's why in every manufacturing step—from alloy selection to final polishing—the rollers are checked against strict quality controls.

A full complement of Needle Rollers, mounted in a precision-made, case-hardened retaining shell, provides a maximum number of contact lines, giving the Torrington Needle Bearing a higher radial load capacity than any other bearing of comparable size.

The Torrington Needle Bearing delivers top anti-friction performance—with low coefficient of both starting and running friction.

For more than twenty years, our Engineering Department has helped designers and manufacturers throughout industry to adapt the unique advantages of the Needle Bearing to their products. Let us help you make the Needle Bearing "standard equipment" in yours.

See our new Needle Bearing Catalog in the 1956 Sweet's Product Design File —or write direct for a catalog.

TORRINGTON NEEDLE BEARINGS
Give you these benefits

- low coefficient of starting and running friction
- full complement of rollers
- unequalled radial load capacity
- low unit cost
- long service life
- compactness and light weight
- runs directly on hardened shafts
- permits use of larger and stiffer shafts

THE TORRINGTON COMPANY

Torrington, Conn. • South Bend 21, Ind.

District Offices and Distributors in Principal Cities of United States and Canada

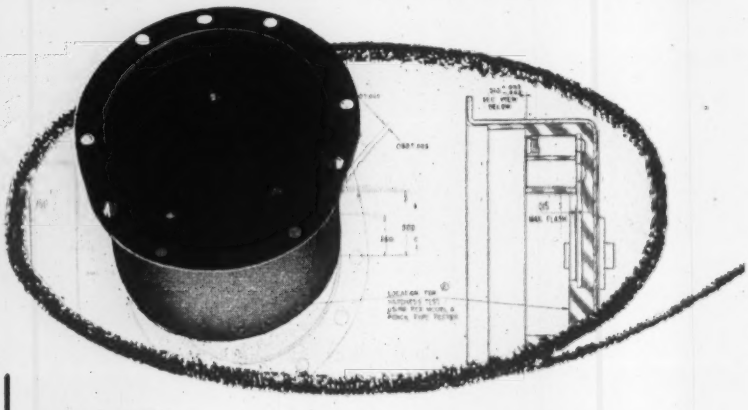
TORRINGTON BEARINGS

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers

—ITEM 247—

THE SHAPE OF THINGS IN MOLDED RUBBER

METER CASE MADE FOR TOUGH AND READY SERVICE BY ACUSHNET



APPLICATION:

Ruggedized Case with molded rubber interior designed by famous electrical instrument manufacturer approved for use by the U. S. Signal Corps.

PROBLEM:
Mold and bond rubber to interior of metal case as shown.
Hold dimensional tolerances to ± .010".

A. Clean metal case thoroughly without distorting.
B. Hold critical distances from the flange to mount studs as shown in the drawing.
C. Stud holes to be kept absolutely free of rubber.

SOLUTION:
Acushnet engineers decided to mold rubber to the flange which automatically compensated for depth tolerances. A one piece mold core provided with locating pins kept the stud holes free of rubber and aided in holding tolerances and producing the unusual contours wanted.

Acushnet is ready to serve you with technical assistance on your next molded rubber and bonded-to-metal part. "APCOTITE" bonding to metal of all polymers is an Acushnet exclusive. Send for brochure describing "APCOTITE" bonding in detail.

Specify "APCOTITE"!

Acushnet

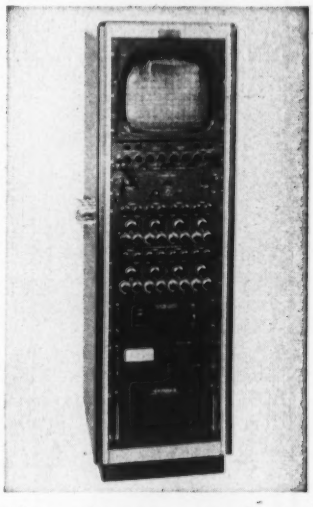
ACUSHNET PROCESS COMPANY
NEW BEDFORD, MASSACHUSETTS

... *Precision Molded* **RUBBER, SILICONES - "APCOTITE" BONDING**

Address all communications to 762 Belleville Ave., New Bedford, Mass.

—ITEM 248—

Engineering Equipment



eration and pressure can be measured. Overall accuracy is within 2 per cent. Indicator is designed for 30-cycle per second and over ac, as well as dc, operation. **Electromec Inc.**, Strain Gage Oscilloscope Dept., 5121 San Fernando Rd., Los Angeles 39, Calif.

—Circle ITEM 94

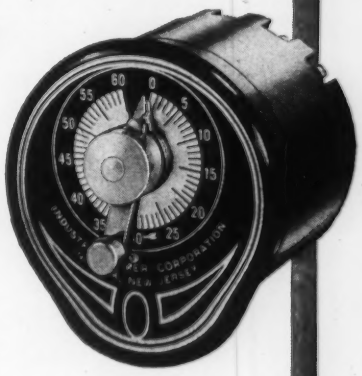
Timer Kit

has parts for four multi-cam timers

A basic set of components, from which the designer can assemble timers and a large variety of electrical and mechanical devices, is provided in the Multi-Cam timer kit. The kit contains all the parts necessary to assemble a 3-cam, a 6-cam, a 9-cam and a 12-cam timer. All parts are standard production items, so that timers can be produced in quantity from the prototype. Kit is supplied in a wooden cabinet, and all motors, switches, cams, gear racks, hardware, tools and an instruction book are included. **Industrial Timer Corp.**, 1407 McCarter Highway, Newark, N. J.

—Circle ITEM 95

need quick service on TIMERS for automatic control?



Time Delay Timers

The more automatic control problems we get, the better we like it. For while it's true each automatic control job is a bit different from the rest, the record shows that our 19 years of timer experience has given us the special knowledge it takes to give you the right answers, and in near-record time.

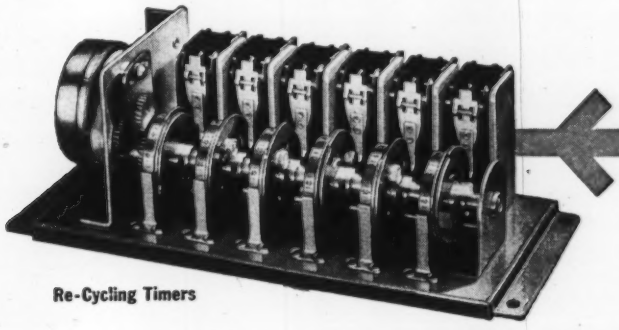
If one of our standard timers won't do your job — or one of the 721 combinations we have thus far developed from our 17 basic units — our engineers will go right to work to develop a new combination that's the one for you. That's the way we grow — and we like it.

We manufacture a complete line of timers in these 4 broad classifications:

TIME DELAY TIMERS • INTERVAL TIMERS
RE-CYCLING TIMERS • RUNNING TIME METERS

And since we maintain large stocks of our 17 basic units, we can assure you of rapid deliveries — of excellent deliveries even on special orders. So whatever your automatic control problem, you have everything to gain by submitting it to our timer specialists. They'll give you a profitable answer — almost with the speed of automatic control itself.

Interval Timers



Re-Cycling Timers

Running Time Meters

Timers that Control the Pulse Beat of Industry

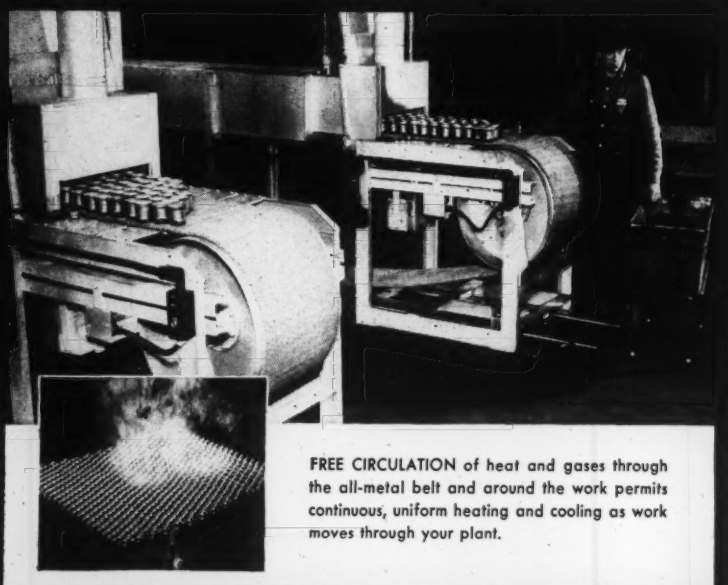
INDUSTRIAL TIMER CORPORATION

1413 McCARTER HIGHWAY, NEWARK 4, N. J.

—ITEM 249—

Cambridge

WOVEN WIRE CONVEYOR BELTS take the "hot spots" out of ANNEALING & BRAZING



FREE CIRCULATION of heat and gases through the all-metal belt and around the work permits continuous, uniform heating and cooling as work moves through your plant.

By combining controlled movement with free circulation of process atmospheres, Cambridge Woven Wire Conveyor Belts eliminate batch annealing and brazing. There is no formation of "hot spots" which produce local stresses. Continuous, belt-to-belt flow through subsequent quenching and washing operations as well as heating, cuts costs and provides fast, uniform production.

REGARDLESS OF YOUR INDUSTRY...

... metalworking, food, chemical, glass and ceramic ... whether the machines are for your own operation or resale, you'll find "free circulation" only one property of Cambridge belts that makes combined movement and processing practical and economical. Open mesh construction also provides rapid drainage of process solutions. Belts are corrosion resistant and impervious to heat damage, even at 2100°F. They have no seams, lacers or fasteners to wear more rapidly than the body of the belt. Cambridge Woven Wire Belts are made in any size, mesh or weave; from any metal or alloy. Special surface attachments are available to hold products during inclined movement.

Call in your Cambridge FIELD ENGINEER to discuss how you can cut costs by continuous operation. Look under "BELTING, MECHANICAL" in your classified phone book. OR, write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

Department N, Cambridge 2, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

Stress Relief

OVER the past few weeks, J. P. Henderson had the opportunity to visit about, seeing many old friends and picking gems from a number of settings. Here he hands some of them on.

Big or Small?

One of the first of the controversial items I heard discussed was the big company versus the small as a desirable place to work. Now this is an old question, which can be argued without end, breaking down largely to personal taste. But the new twist here was the "conversion," so to speak, of a small-company man, disgruntled and disappointed that he had not cast his lot with a larger concern.

"Until recent years," he said, "I've been pointing out the advantages of a small outfit: More freedom to move around, more chance to express oneself. I advised my own sons that way and a lot of other young persons also. Maybe I was correct ten years ago, but today I believe I would be wrong.

"Nowadays I see my counterparts in large corporations enjoying a lot better living than I ever dreamed of. I get three weeks vacation, and that's it. They get the same, but on top of that they enjoy many "privileges" that don't go with my job or my company.

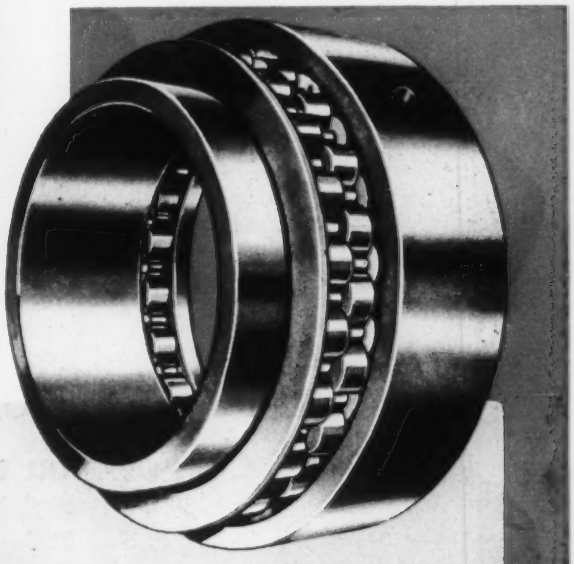
"I see these men provided with all sorts of facilities in their work which a smaller company cannot afford. Then on top of that there are cooperative investment and stock-buying deals, extra bonuses and such things which put even junior executives in pretty fair financial condition.

"Perhaps I am getting soft but for an equivalent effort in such a concern I believe I would not only be making more money but enjoying a higher scale of living for the same outgo.

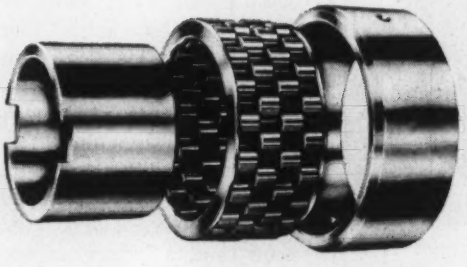
"Of course, there is always the disconcerting thought that I

—ITEM 250—
For More Information Circle Item Number on Yellow Card—page 19

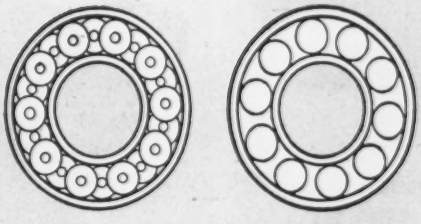
More Load Capacity!



—because more rollers support the load



In Orange "Staggered" Roller Bearings the load is distributed over many short rollers, instead of a few full length rollers.



End views of a Staggered bearing and conventional bearing show how the staggered rollers provide a multiplicity of contact points within the loaded zone.

Outstanding for Heavy-Duty Service

ORANGE "STAGGERED" ROLLER BEARINGS

Wherever radial loads are extremely heavy—operating conditions are unusually severe—and even, precision running is absolutely essential . . . install Orange "Staggered" Roller Bearings.

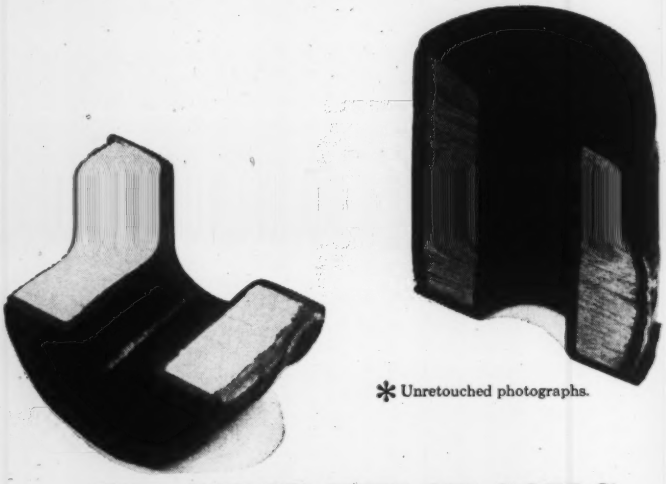
The use of many short rollers in staggered arrangement, instead of fewer long rollers, provides the following advantages:

- Extra load capacity that does the work of larger conventional bearings.
- Smooth, precision running due to uniform distribution of load.
- Elimination of skewing tendencies of long rollers.
- Longer bearing life and extra margin of safety for your installations.

Orange "Staggered" Roller Bearings are available in a full range of standard sizes, fully interchangeable with other bearings in the 200 and 300 series. Engineering service and stocks in all industrial centers. Write for Engineering Data Book.

ORANGE

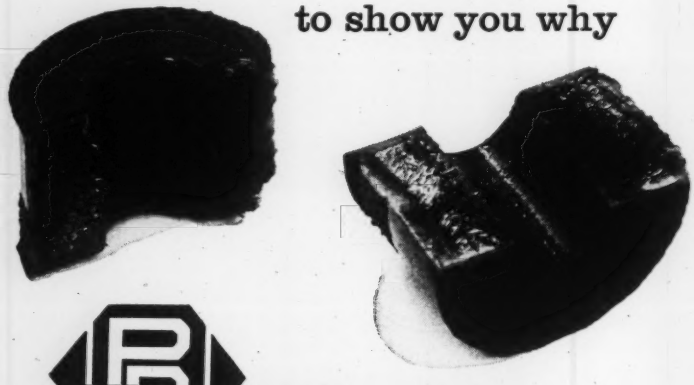
ORANGE ROLLER BEARING CO., INC., 556 Main Street, Orange, N. J.



✻ Unretouched photographs.

WE SPLIT RELAY COILS

to show you why



P&B RELAYS

are the best

These two coil cross-sections illustrate one of the many reasons why P&B's engineering skills and manufacturing facilities have made it *first* in the relay field.

The lower split coil was impregnated by the most universally accepted method.

Note how the varnish failed to penetrate beyond the first few strands—leaving air- and moisture-trapping spaces—allowing strands to pull loose when sawed. *This trapped moisture sets up electrolytic action, causes eventual breakdown.*

Note, however, that the P&B coil above *has* no such "empty" spaces. All strands are solidly embedded in varnish—*completely protected* against moisture and electrolysis.

Centrifugal impregnation, a method exclusive with P&B in the relay field, forces varnish *completely through* the coil—displacing all air and moisture—filling all spaces permanently.

It's one of many excellent reasons why, when you need a relay . . . *of any size, any type, for any application* . . . your smartest move is to P&B and Sterling Relays.

Potter & Brumfield

PRINCETON, INDIANA

Subsidiary of AMERICAN MACHINE & FOUNDRY COMPANY

Stress Relief

wouldn't have gotten as far in the first place, had I started work with the larger company."

Ignorance Is Not Always Bliss

All of my friends were not unhappy when I visited them, but there was another unusual case that interested me.

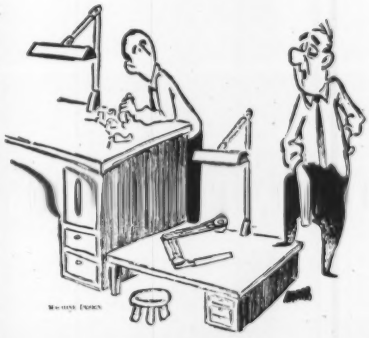
"Generalizations are bad," said this engineer, "but I'm about to advise anyone not to take a job with a self-made man.

"I never expected to take an attitude which would make it appear that I was snobbish about a college degree, but I'm about fed up with working for a man who doesn't have one. Smart as he is, and capable as he is, there are amazing gaps in his knowledge. On many things that most of us accept as second nature, he displays a distressing naivete.

"He unfortunately announces some miscellaneous fact with the preface: 'Say, Harry, did you know that. . . ' Innocent sounding enough isn't it? But how do you answer? And how do you answer after it's happened 100 times? If you say 'why no, boss' he ultimately thinks you're pretty dumb. If you say 'yes,' it robs him of his position as mentor and he turns sour on you. Right now he's curdled on me and he's let fly a few sarcastic remarks about these know-it-all university graduates. For the next few weeks I'll have to play dumb."

I tried to console him with the thought that it was easier to be smart and play dumb, than be dumb and play smart.

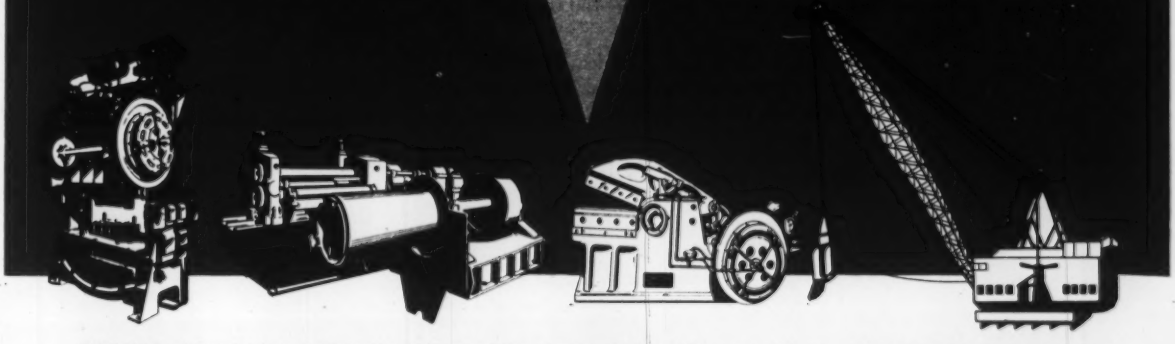
—J. P. HENDERSON



"Seen Shorty?"

OPERATORS OF POWER-DRIVEN MACHINES HAVE PROVED THAT

IT OPERATES BEST WHEN FAWICK-EQUIPPED



POWER-DRIVEN MACHINES EQUIPPED WITH FAWICK CLUTCHES AND BRAKES PROVIDE BETTER PRODUCTION, WITH GREATER OPERATING SAFETY AND LOWER MAINTENANCE.

Extensive job studies have proved that FAWICK's accurate air operation and control result in increased production, reduced scrap losses, less operator fatigue and less machine down-time.

The aggressive FAWICK program of power transmission product development and the expansion of FAWICK field engineering facilities, are designed to increase your machine production and efficiency. The nearest Fawick representative or the Home Office will show you how quickly and easily this can be done. Remember—your machines will operate *best* when FAWICK-EQUIPPED!

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FAWICK CORPORATION
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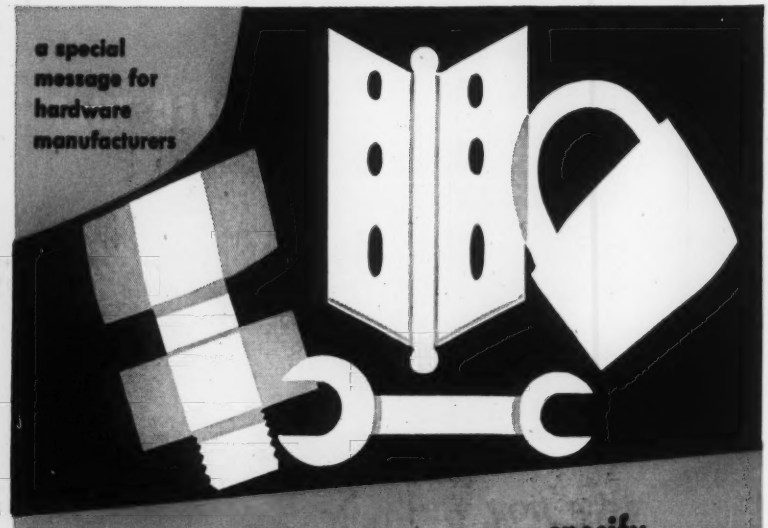
In Canada: Fawick Canada, Ltd., Toronto, Montreal

FAWICK Airflex
INDUSTRIAL CLUTCHES AND BRAKES



need a finish for protection—decoration—identification? specify IRIDITE®

Specify Iridite . . . for corrosion protection during storage or use . . . for a firm and lasting base for paint . . . for extra quality and eye-appeal . . . for low cost color coding of finished parts.

ON ZINC AND CADMIUM you can get highly corrosion resistant finishes to meet any military or civilian specifications and ranging in appearance from olive drab through sparkling bright and dyed colors.

ON COPPER . . . Iridite brightens copper, keeps it tarnish-free; also lets you drastically cut the cost of copper-chrome plating by reducing the need for buffing.

ON ALUMINUM Iridite gives you a choice of natural aluminum, a golden yellow or dye colored finishes. No special racks. No high temperatures. No long immersion. Process in bulk.

ON MAGNESIUM Iridite provides a highly protective film in deepening shades of brown. No boiling, elaborate cleaning or long immersions.

AND IRIDITE IS EASY TO APPLY. Goes on at room temperature by dip, brush or spray. No electrolysis. No special equipment. No exhausts. No specially trained operators. Single dip for basic coatings. Double dip for dye colors. The protective Iridite coating is not a superimposed film, cannot flake, chip or peel.

WANT TO KNOW MORE? We'll gladly treat samples or send you complete data. Write direct or call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

Iridite is approved under government specifications

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Manufacturers of Iridite Finishing for Corrosion Protection and Paint Systems on Non-Ferrous Metals, ARP Plating Chemicals.
WEST COAST LICENSEE: L. H. Butcher Co.

THE ENGINEER'S Library

Recent Books

Dynamics of Machinery. *By A. R. Holowenko, associate professor of mechanical engineering, Purdue University; 464 pages, 6 by 9 inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, *$7.50 postpaid.*

This text is concerned with the kinematics and force analysis areas in the general subject of machine design. Particular machines are used as representative design subjects, but the book emphasizes the application of basic design principles to any type of engine where an energy reservoir is needed or where speed control within a cycle is desired. To demonstrate that more than one approach to problems can be used, both analytical and graphical developments are presented.

•

Applied Thermodynamics. *By Earle B. Norris, dean emeritus, school of engineering, Virginia Polytechnic Institute; Eric Therkelsen, late professor of mechanical engineering, Montana State College; and Clarence E. Trent, professor of mechanical engineering, Virginia Polytechnic Institute; 490 pages, 6 by 9 inches, clothbound; published by McGraw-Hill Book Co. Inc., New York; available from* MACHINE DESIGN, *$7.50 postpaid.*

Successor to the two editions of the text entitled *Heat Power* by Norris and Therkelsen, this volume is intended to develop an understanding of the fundamentals of thermodynamics as applied to power generation from heat sources. It also covers new developments including dual-fuel diesel engines, gas turbines, nuclear power, and compressors of both displacement and kinetic types.

Chapters cover internal combustion engines, principles of com-

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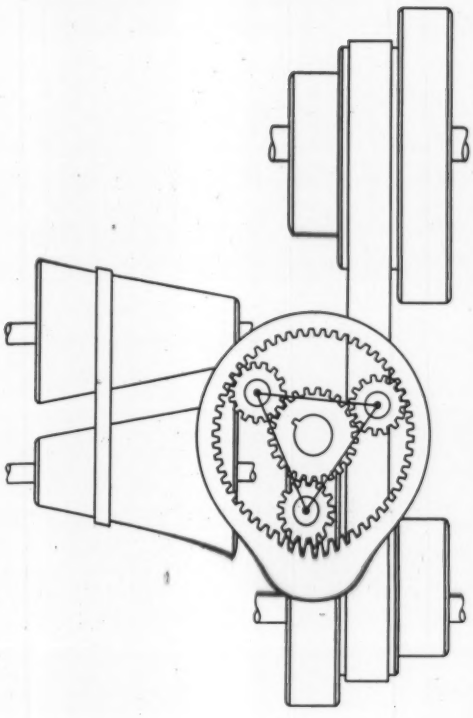

MECHANICAL

Adjustable-Speed

DRIVES

by Leo F. Spector
Associate Editor, MACHINE DESIGN

Most simple, direct, and often least-expensive methods of speed adjustment are those employing mechanical principles.

This two-part series is a basic guide to the selection of all kinds of mechanical adjustable-speed drives:

1. Stepped
2. Stepless, limited range
3. Stepless, infinite range

The first two classes are covered in Part One. The third class is discussed in Part Two which also includes a summary of selection and application factors.

A companion guide to "Adjustable-Speed Electric-Motor Drives" (MACHINE DESIGN—October 1954) . . . "Mechanical Adjustable-Speed Drives" belongs in your working library.

Order your copies today

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SEND ME ____ copies of "MECHANICAL ADJUSTABLE-SPEED DRIVES" at $1.00 per copy

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☐ Remittance enclosed

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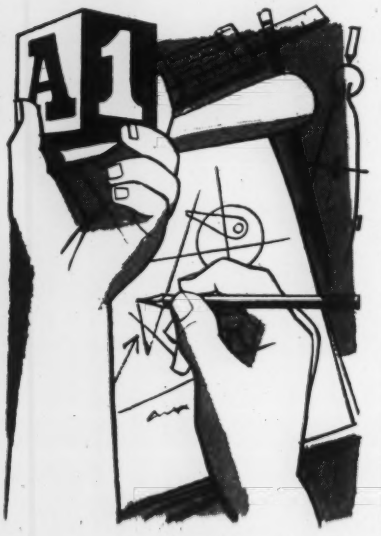
First of its Kind?



consider a ball

Are you working on something that's never been done before . . . something that has been considered "impossible" . . . something that *begins* to look "impossible" to *you*?

Why not consider a ball—a *Universal* Ball? It may be the key to making your new design *work*.

When you use a Universal Ball of chrome or stainless steel you get truest accuracy—tolerances better than ten-millionths of an inch! And there's a Universal Ball size for your every need—smaller than a pinhead . . . large as a golf ball—with many sizes in-between. (Universal Balls come in various metals, too—chrome, stainless steel, bronze, solar, aluminum, and special materials.)

A Universal Ball may move *your* design off the drawing board . . . into production . . . onto the market as fast-selling, profit-making, new merchandise. We guess that's what you'd *like* to accomplish. May we help you do it?

Universal Ball co.

WILLOW GROVE
MONTGOMERY CO., PA.

—ITEM 255—

The Engineer's Library

bustion, work and power, heat and work, performance and cycles of internal combustion engines, properties of steam, steam engine mechanisms and performance, steam boilers and condensers, compressors and refrigeration systems.

♦

Machine Design, 2nd Edition. *By Paul H. Black, professor of mechanical engineering, Ohio University;* 538 *pages,* 6 *by* 9 *inches, clothbound; published by McGraw-Hill Book Co. Inc., New York; available from* MACHINE DESIGN, $7.50 *postpaid.*

Intended as a reference book in mechanical design offices as well as a text for courses in general design, this book begins with references to allied fields with which readers are assumed familiar. In this edition, broader treatment is given to the selection of materials, types of power-transmission apparatus and motor selection.

Other subjects include fabrication and processes, detachable fasteners, springs, pressure cylinders, shaft couplings, clutches and brakes, friction and lubrication.

♦

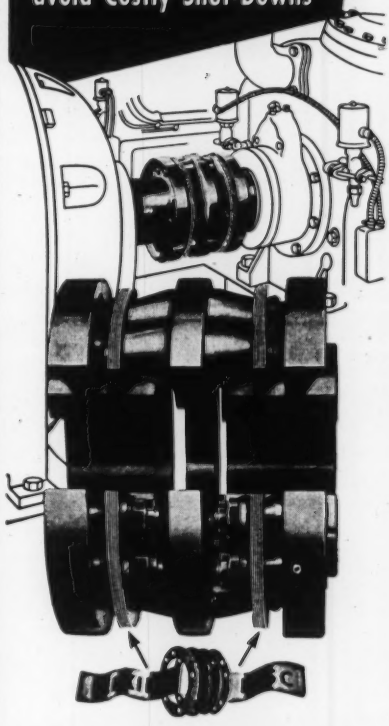
Die Design Handbook. *Edited by Frank W. Wilson;* 722 *pages,* 6 *by* 8⅞ *inches, clothbound; published by McGraw-Hill Book Co. Inc., New York, for the American Society of Tool Engineers; available from* MACHINE DESIGN, $14.50 *postpaid.*

Concerned with cold metal pressworking operations, this handbook is intended for the designers of dies and products fabricated in dies. Twenty-seven sections cover stampings design, die sets and components, press feeding and unloading, die and stamping materials, and pressworking terminology.

♦

Engineering Metallurgy. *By L. F. Mondolfo, professor of metallurgical engineering, Illinois Institute of Technology, and Otto Zmeskal, research professor, College of Engineering, Department of Mechanical Engineering, University of Florida;* 397 *pages, 6 by 9 inches, clothbound; published by McGraw-Hill Book Co. Inc., New*

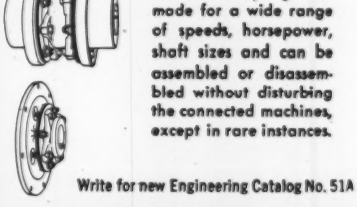
Specify **THOMAS** ALL METAL **FLEXIBLE COUPLINGS** for Power Transmission to avoid Costly Shut-Downs



Patented Flexible Disc Rings of special steel transmit the power and provide for parallel and angular misalignment as well as free end float.

DISTINCTIVE ADVANTAGES

FACTS	EXPLANATION
NO MAINTENANCE	Requires No Attention. Visual Inspection While Operating.
NO LUBRICATION	No Wearing Parts. Freedom from Shut-downs.
NO BACKLASH	No Loose Parts. All Parts Solidly Bolted.
CAN NOT "CREATE" THRUST	Free End Float under Load and Misalignment. No Rubbing Action to cause Axial Movement.
PERMANENT TORSIONAL CHARACTERISTICS	Drives Like a Solid Coupling. Elastic Constant Does Not Change. Original Balance is Maintained.



Thomas Couplings are made for a wide range of speeds, horsepower, shaft sizes and can be assembled or disassembled without disturbing the connected machines, except in rare instances.

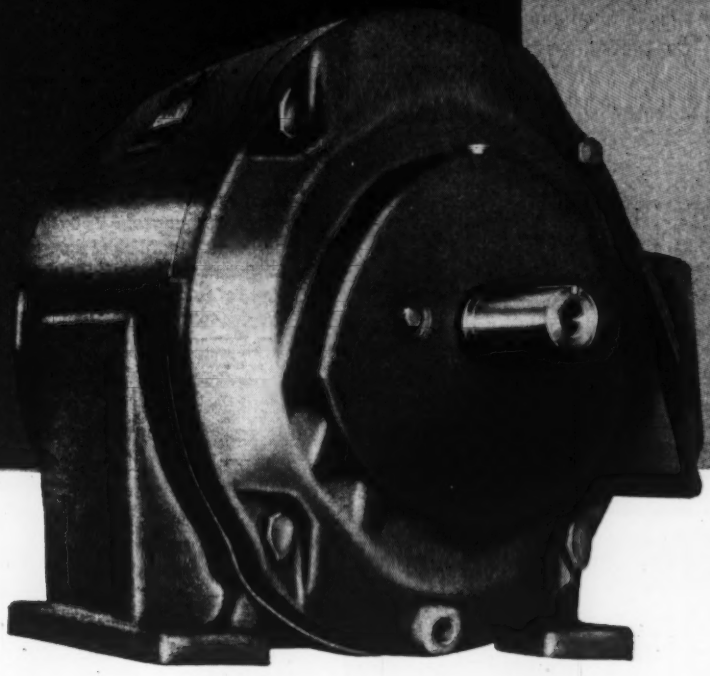
Write for new Engineering Catalog No. 51A

THOMAS FLEXIBLE COUPLING CO.

WARREN, PENNSYLVANIA, U.S.A.

—ITEM 256—

Totally Protected



FROM CORE TO COVER

RELIANCE *Totally-Protected* MOTORS

The total protection concept of design and construction armors Reliance A-c. Motors against everyday hazards, with little or no maintenance. Total protection is made up of extra features like:

Slot cell insulation of Double Backed Mylar

Dynamically balanced rotor for vibrationless operation

Entire insulation system impervious to acids, moisture and oils

Metering plate regulates grease flow to bearing

Ventilation louvres positioned high and dry in end brackets

There are 100 of these extra core to cover protection features in Reliance Motors. Each point is covered in our bulletin, "Check the 100 Facts". Why don't you write for one and get all the details? B-1510

RELIANCE ELECTRIC AND ENGINEERING CO.

Cleveland 10, Ohio • Offices in Principal Cities

Canadian Division: Welland, Ontario

—ITEM 257—

For More Information Circle Item Number on Yellow Card—page 19

Mr. Design Engineer:

Durakool is the STANDARD OF QUALITY, DURABILITY AND LIFE

Durakool pressurized all-steel mercury tilt switches have more than made good on what may have seemed like extravagant claims a few years ago. The list of Durakool successes grows each year. Seven sizes, 1 to 65 amperes. 3 to 4 weeks delivery. Your production schedule is met.

Send for BULLETIN 525

Steel Durakool MERCURY SWITCHES

See telephone directory for local distributor, or write.

DURAKOOL, INC.

ELKHART, INDIANA, U.S.A. • 700 WESTON RD., TORONTO, CANADA

—ITEM 258—

Another of the Reasons Behind Brad Foote Quality—

TOOTH SPACING

• 99% of gear drawings do not specify tooth spacing. For most applications, industry generally believes that competent gear manufacturers, working by standard AGMA practices, will produce gears within the limitations required for easy assembly and good load transmission.

• Occasionally, however, on very precise jobs you may find it necessary to specify extreme accuracy of tooth spacing and nonadjacent tooth spacing. Applications such as radar mounts, timing mechanisms, indexing mechanisms—all may require closer tooth spacing tolerances than are obtainable with average equipment in the hands of regular gear manufacturers.

• BRAD FOOTE welcomes precision jobs like these. We can add to highly specialized equipment specific experience in meeting this, as well as many other demanding requirements for special gear production.

• Prove to yourselves the savings that BRAD FOOTE quality can mean. Let us quote on the gear requirements for your next program.

BRAD FOOTE MAKES ALL TYPES OF GEARS—IN A COMPLETE RANGE OF STYLES AND SIZES

BRAD FOOTE GEAR WORKS, INC.

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subsidiaries | AMERICAN GEAR & MFG. CO. Lemont, Illinois Phone Lemont 920 | PITTSBURGH GEAR COMPANY Phone SPalding 1-4800 Pittsburgh 23, Penn.

—ITEM 259—

The Engineer's Library

York; available from MACHINE DESIGN, $7.50 *postpaid.*

This text is prepared for engineers and sudents who need to be familiar with metallurgy but for whom this field is not a primary interest. The first of fifteen chapter concerns the extraction of metals. Several chapters are devoted to basic theory as an introduction to practical applications. Casting, plastic deformation, annealing and joining are covered separately. Final chapters treat particular ferrous and nonferrous metals.

Association Publications

An Annotated Bibliography On Noise, Its Measurement, Effects and Control. 364 *pages, 6¼ by 8⅞ inches, paperbound; published by and available from Industrial Hygiene Foundation of America Inc., Mellon Institute,* 4400 *Fifth Ave., Pittsburgh* 13, *Pa.,* $7.50 *per copy.*

Intended as a reference for engineers and managers concerned with problems of excessive noise, this volume provides 2336 references listed chronologically in five sections. The sections concern measurement of noise, effects of noise, measurement of hearing loss, reduction and control of noise, and general literature. Indexes of subjects and authors follow the main sections.

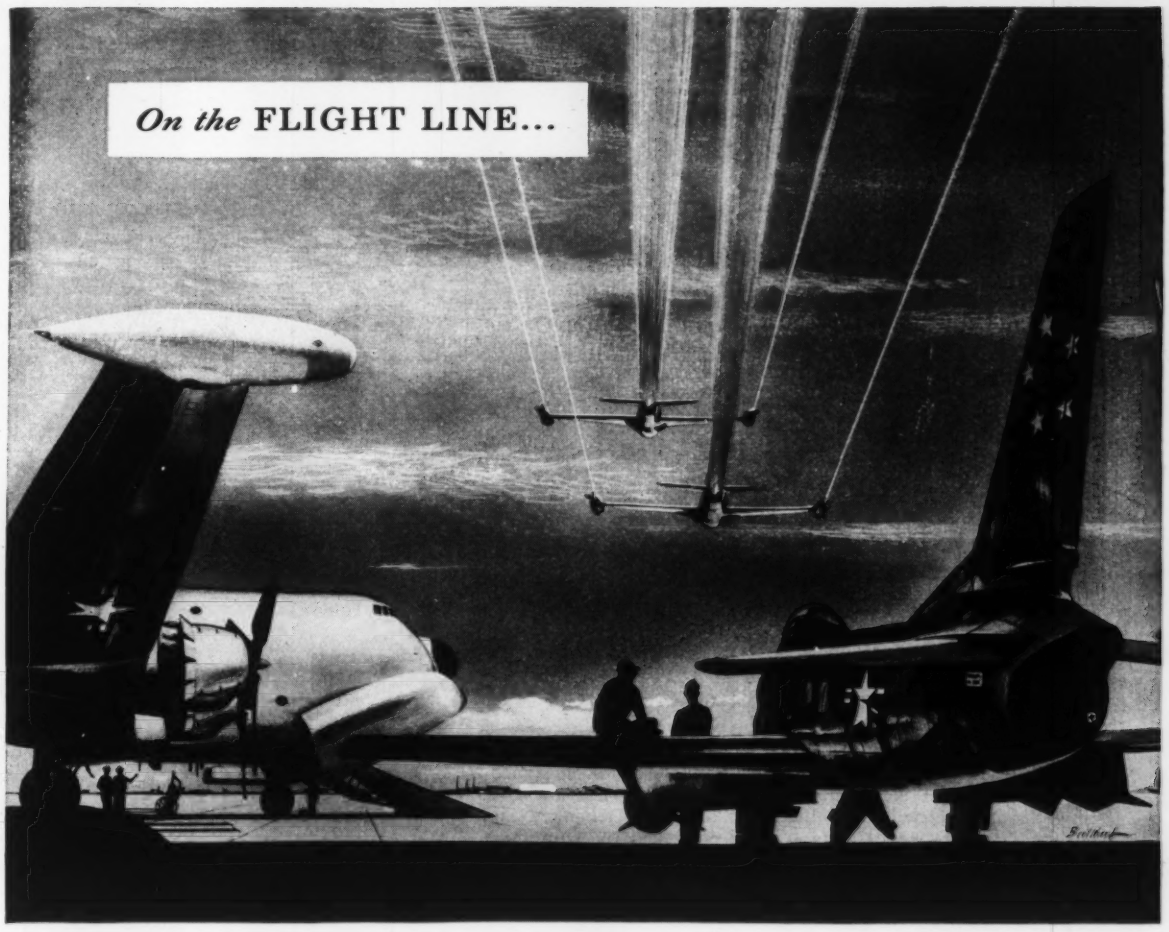
•

Hot Rolled Carbon Steel Strip. 24 *pages, 8½ by* 11 *inches, paperbound; available from American Iron and Steel Institute,* 350 *Fifth Ave., New York* 1.

This revised section of the AISI Steel Products Manual covers metallurgical aspects, manufacturing practices, quality descriptions and chemical composition of hot rolled carbon steel strip.

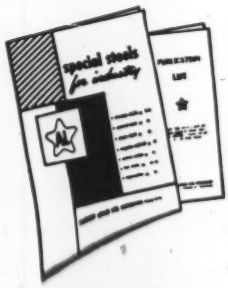
•

Specifications and Tests for Electrodeposited Metallic Coatings. 104 *pages, 6 x 9 inches, paperbound; published by and available from American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.,*



FIRST COST *can be the* LEAST COST

if it's the LAST COST



★ ★ ★ ★ The Allegheny stainless and super high-temperature steels used in jet and rocket aircraft engines and equipment are pure economy, because they do the job that's required of them, and they *last!* They stand up under metal-killing conditions of heat, load and corrosion, and they're dependable.

There are lots of other jobs for stainless steel that aren't as spectacular, or perhaps as tough, as those aboard a jet. Like, for example, in hospital or kitchen equipment —or in cars, trains, appliances, buildings, etc. But, in these and thousands of other cases, stainless again gets the call. And usually, it's for the same big reason . . . because it not only does the job better, but lasts longer and costs less in the long run than any other material on the market.

And that brings up this question: where can Allegheny Stainless help *you* either to make money, or to save it? If you have a product or equipment problem, call us in . . . let our Engineering and Research Staff lend a hand. *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.*

W&D 3599 B

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For These Publications

1. SPECIAL STEELS FOR INDUSTRY . . . 16 pages of essential data on the proper selection and application of principal AL special alloy products: stainless, tool and electrical steels and sintered carbides.

2. PUBLICATION LIST . . . a complete listing of all AL publications, both technical and nontechnical (over 100 in all), with a handy order form for your convenience.

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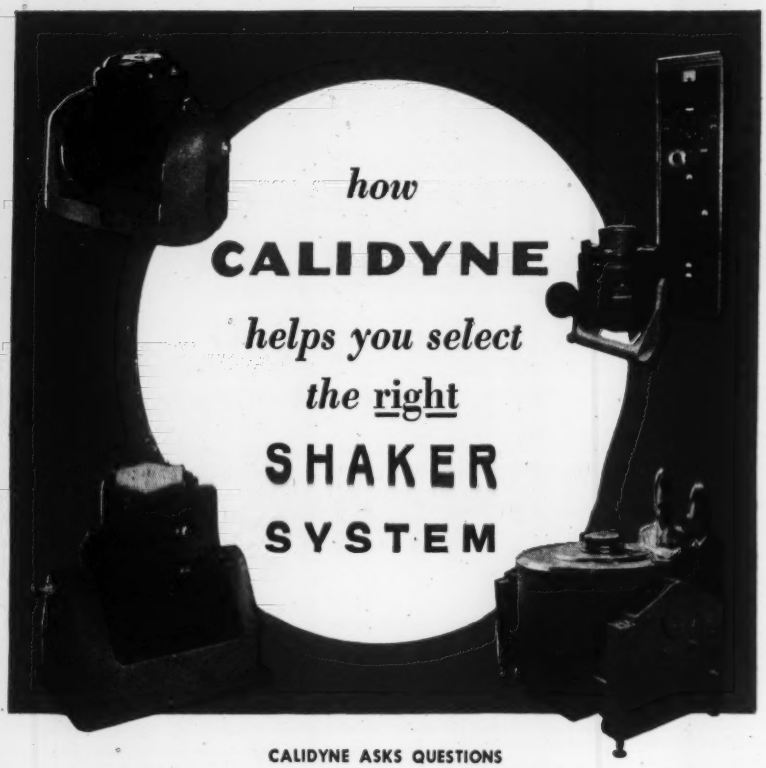
Make it BETTER-and LONGER LASTING-with

AL Stainless Steel

AL ALLEGHENY LUDLUM ®

Warehouse stocks carried by all Ryerson Steel plants

—ITEM 260—
For More Information Circle Item Number on Yellow Card—page 19



CALIDYNE ASKS QUESTIONS

When you inquire about Calidyne Shaker Systems, you're asked "What *type* of vibration testing is required — conventional environmental testing? Fatigue testing? Structural response determination? Mechanical noise reduction?" Further, "What are your present, and anticipated, requirements for force, frequency, and stroke?" In this way, Calidyne can recommend the equipment which will provide *maximum* usefulness for your investment, with as much flexibility as possible for future needs.

CALIDYNE DELIVERS

To meet your requirements, Calidyne offers complete Shaker Systems ranging in force output from 25 to 12,500 pounds. Systems consist of one or more electrodynamic Shakers, a rotary or electronic power supply, a control console and various optional accessories for monitoring, measuring or automatically cycling tests. Calidyne Shakers feature greater useful force output through lighter armatures, true linear armature motion, rugged construction. Certain Calidyne power supply units, also, will operate Shakers of widely different force outputs. Any accessory may be added to a basic system at any time, without costly revamping or modification.

CALL CALIDYNE

For competent help in solving your vibration testing problems, or technical data on any Calidyne Shaker System, call Calidyne now.

THE CALIDYNE COMPANY

120 CROSS STREET, WINCHESTER, MASSACHUSETTS

SALES REPRESENTATIVES:

WALTHAM, MASS. Robert A. Waters, Inc. Waltham 5-6900
NEW HAVEN, CONN. Robert A. Waters, Inc. Fulton 7-6760
NEW YORK CITY AREA G. C. Engel & Associates Rector 2-0091
RIDGEWOOD, NEW JERSEY G. C. Engel & Associates Gilbert 4-0878
PHILADELPHIA, PA. G. C. Engel Chestnut Hill 8-0892
NORTHERN NEW YORK Technical Instruments, Inc. Waltham, Mass. Waltham 5-8445
CLEVELAND, OHIO M. P. Odell Co. Prospect 1-6171
DAYTON, OHIO M. P. Odell Co. Oregon 4441
DETROIT, MICHIGAN M. P. Odell Co. Superior 8-5114
WASHINGTON, D. C. F. R. Jodon, Inc. Hobart 2-4300
SOUTHEAST W. A. Brown & Assoc. Alexandria, Va. Overlook 3-6100
CHICAGO, ILLINOIS Hugh Marsland & Co. Ambassador 2-1555
INDIANAPOLIS, INDIANA Hugh Marsland & Co. Glendale 3803
MINNEAPOLIS, MINN. Hugh Marsland & Co. Colfax 7949
DALLAS, TEXAS John A. Green Co. Fleetwood 7-7385
HOLLYWOOD, CALIFORNIA G. B. Miller Co. Hollywood 2-1195
SAN FRANCISCO, CALIF. G. B. Miller Co. Lytell 3-3438
ALBUQUERQUE, NEW MEXICO G. B. Miller Co. Albuquerque 5-8606
SEATTLE, WASH. G. B. Miller Co. Lander 3320
CANADA Measurement Engineering Ltd. Arnprior, Ont., Phone 400 Toronto, Ont., Mayfair 8860
EXPORT Rocke International Corp. 13 East 40th St., N. Y. 16, N. Y. Murray Hill 9-0200

The Engineer's Library

$1.85 *per copy to nonmembers.*

This booklet contains 17 specifications, methods of test and recommended practices prepared jointly with the American Electroplaters' Society. Coatings treated are zinc, cadmium, nickel, lead and chromium on steel; nickel and chromium on copper and zinc; and chromate finishes. Three methods of test are included and recommended practices are mainly the preparations for electroplating certain alloys.

Manufacturers' Publications

How To Organize and Operate Photographic Service Departments. *60 pages, 5¾ by 8½ inches, paperbound; published by and available from Eastman Kodak Co., Rochester 4, N. Y., 50c per copy.*

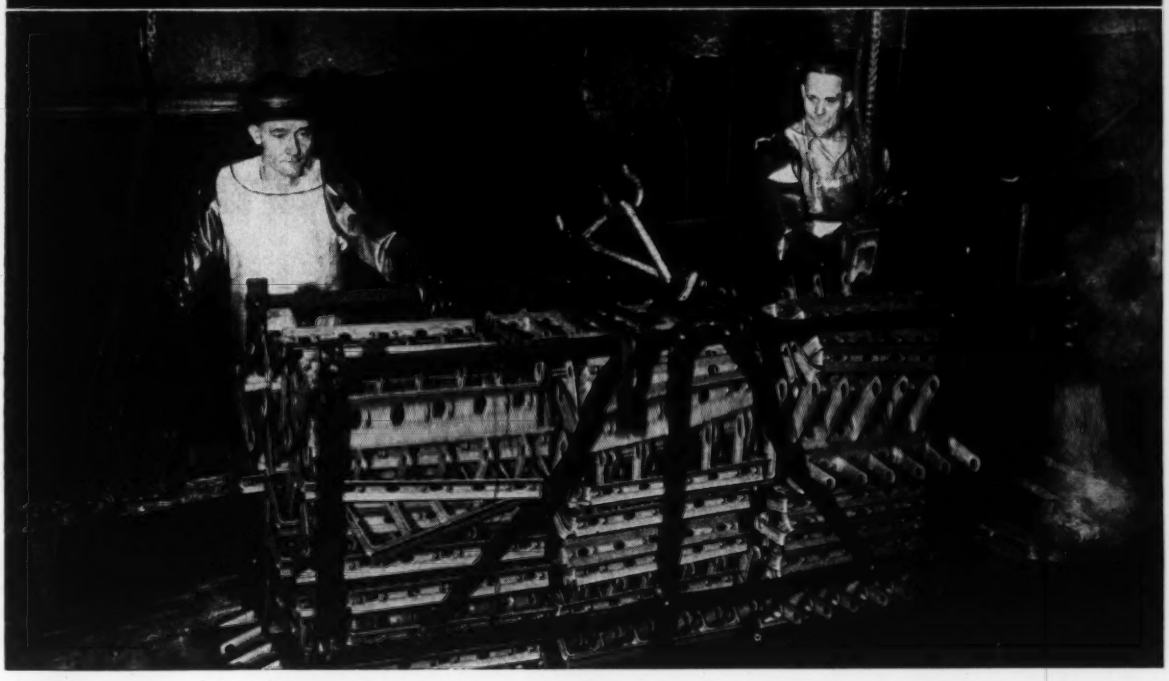
This booklet deals with two problems in industrial photography—starting a photographic service department, and operating one efficiently after establishment. The first part concerns the functions of plant photography, typical applications, and sources of personnel and facilities. Chapters treat the organization, administration and operation of a photographic service department. Kinds of activity covered in the second group are photocopying, duplication and graphic arts services.

•

Preparing for Patent-Hood. *By Elton T. Barrett, president, CGS Laboratories Inc.; 20 pages, 6½ by 8½ inches, paperbound; published by and available from CGS Laboratories, Inc., 391 Ludlow St., Stamford, Conn.*

Why and how to get a patent is the subject of this cartoon-illustrated booklet. Beginning with the recognition and evaluation of the patentable idea itself, the discussion considers the importance of dates, the work and worth of the patent attorney, processing in the patent office, claims, the economic importance of patents, and foreign patents.

How's this for corrosion control?



Carpenter Stainless No. 20 pickling rack still in H_2SO_4 service after 5½ years!

Steady exposure to 5-15% sulphuric acid at temperatures up to 200°F for over 5½ years is the service record of this pickling rack made from Carpenter Stainless No. 20. It supports heavy loads of pole line hardware during pickling. Dependable corrosion resistance in the steel is invaluable.

Ordinary steels lasted but a short time on this application. Then, Carpenter Stainless No. 20 was put to work. The result is added safety for the workers, substantial savings in replacements, and uninterrupted production.

Today industry is finding a host of uses for this super corrosion-resisting steel. A wide variety of products of No. 20 can be purchased already fabricated . . . or you can build your own. In addition to hot sulphuric acid, this unique steel resists attack by a long list of other corrosives.

Whatever your corrosive application, talk to Carpenter first about the cost-saving advantages of No. 20. Over 70 years' experience in the development and manufacture of specialty steels are at your service when you contact your nearest Carpenter Mill-Branch Warehouse, Office or Distributor. *The Carpenter Steel Co., 120 W. Bern St., Reading, Pa.*

Partial list of Stainless No. 20 products now being fabricated:

Agitating equipment
Baskets
Centrifugal pumps and parts
Coils
Heating and cooling
Dehydrators
Exchangers, Heat
Fans
Fastenings (all types of standard and special design)
Fittings
Grommets
Hangers
Instruments
Heat and temperature
Industrial liquid level
Mixers
Nozzles
Pails for sulphuric acid
Pipe
Processing equipment (food and chemical industry)
Pump parts
Screws
Tanks, welded
Thermocouple wells
Tube
Valve parts
Valves
Vessels, welded
Weld rods
Wire
Baskets
Cloth
Stranded
And others

Carpenter Stainless No. 20-Cb is available from The Carpenter Steel Company, Alloy Tube Division, Union, New Jersey, in the forms of tubing, sheet, strip, pipe and plate; and Stainless No. 20 in the forms of bars, billets and wire.

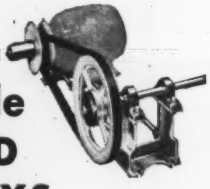
Our new leaflet "*Positive Protection*" has a more complete list of available products made from No. 20. If you haven't a copy, please drop us a line.

Carpenter STEEL

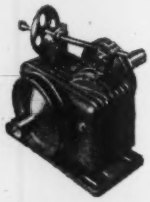
Super Corrosion-Resistant Stainless

Pioneering in Improved Tool, Alloy and Stainless Steels Through Continuing Research
Export Department: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

LOVEJOY



Variable SPEED PULLEYS



SELECT-O-SPEED TRANSMISSIONS

Save You Money

HERE'S WHY:

- ECONOMICAL IN COST compared to other variable speed transmission equipment. Simple in design but rugged in construction to give you long dependable service.
- EASILY INSTALLED on new or old equipment. Just as easy to operate. Finger-tip adjustment gives the right speed instantly.
- MAINTENANCE IS NEGLIGIBLE. No complicated mechanisms to get out of order. All parts can be readily inspected. Belts can be quickly adjusted or replaced.

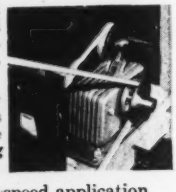
Lovejoy Variable Speed Pulleys

are available in a complete range of sizes from fractional to 15 hp., ratios to 3 to 1.

Shown is a typical Lovejoy countershaft unit controlling speed of automatic spring coiler.

Lovejoy Select-O-Speed Transmissions

can be supplied with hand wheel or lever control. Fractional to 5 hp., ratios to 10 to 1.



This Lovejoy Select-O-Speed is used to control the speed of a printing press.

For your variable speed application, there is a type and size Lovejoy unit that will give you initial economy, dependable performance and long service life.

GET FULL DETAILS NOW!

Request Catalog

LOVEJOY FLEXIBLE COUPLING CO.

4818 W. LAKE STREET • CHICAGO 44, ILLINOIS

Mfrs. of Flexible Couplings, Variable Speed Pulleys and Transmissions, Motor Bases and Universal Joints.

—ITEM 263—

New Machines

Materials Handling

Vibratory Parts Feeder: Model EB-23-B unit provides clockwise and counterclockwise feed of parts up to 4 in. long on single or dual discharge tracks. Electromagnetic motor moves the parts around the 1⅞-in. wide spiral track. The speed of feed is regulated by adjustment of a rheostat to change amplitude of vibration. Standard unit operates on 110 v, 60 cycle motor. Motors rated 220/440 v, 60 cycle are also available. The machine is equipped with either a 24 or 30-in. diam bowl. *Syntron Co., Homer City, Pa.*

Portable Lift: Manually propelled hydraulic lift with 2000-lb capacity is designed for one-operator handling and stacking of heavy loads. Equipped with hand or battery-powered lifting mechanism, it can function as platform truck, straddle fork truck, portable elevator and shop crane. Adjustable legs straddle the load or ride beneath it. Turning radius is 60 in. Battery-powered models have a built-in charger. Range of lift is 2 to 56 in. Overall height is 78¼ in.; overall length, 52 in. *Oster Mfg. Co., Cleveland, O.*

Hopper Feeder: Model 2300 elevating conveyor feeds, transfers and pushes slugs through an induction coil and delivers heated parts to a production machine. The unit accommodates cylindrical parts from ¼ to 1½ in. diam and from ⅜ to 3 in. long. Hopper capacity is 10 cu ft, and elevating belt is 6 in. wide. Motor is rated ¼-hp, 220/440 v, three phase, with adjustable-speed drive. *Feedall Inc., Willoughby, Ohio.*

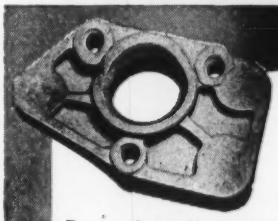
Metalworking

Grinding Machines: Four Filmatic hydraulic grinding machines perform traverse and infeed grinding operations on medium size parts. Two units, designated 10 in. L and 14 in. L, are light types

Complicated Electronic Parts Now

Ep Co

INVESTMENT CASTINGS



Base plate for super-sensitive measuring device which must be dimensionally stable at wide variations in temperature.
Material—Invar

Wave Guide
Material—Aluminum #356T6

Lever arm for an Electronic Computer
Material—Stainless Steel type 303

Send Us Your Drawings For Quotations On Parts Where EXTRA QUALITY Must Be Maintained.

Ep Co

ENGINEERED PRECISION CASTING CO.

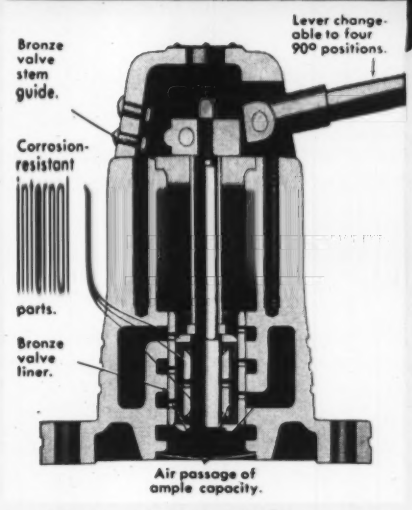
Box MD 68 Matawan, N. J.

—ITEM 264—

AIR POWER CAN BE COSTLY!

Eliminate breakdown and reduce maintenance by choosing Rivett Valves!

LONG LIFE ASSURED BY SIMPLE, COMPACT DESIGN


Lever changeable to four 90° positions.
Bronze valve stem guide.
Corrosion-resistant internal parts.
Bronze valve liner.
Air passage of ample capacity.

– at new low prices!

See Rivett Valves at Booth 324
A.S.T.E. Show, Chicago, March 19-23.

Flexibility for designing any circuit

Be confident of the continuous, uniform control of air by using any of the complete line of Rivett Air Valves. Design assures easy operation, long life — precludes need of adjustment—prevents leakage. Readily disassembled for servicing or modification.

Recommended for pressures up to 150 P.S.I., these valves are available in 5 sizes: ¼", ⅜", ½", ¾" and 1".

Get this important booklet!

Working drawings, specifications, cut-away views —all data requisite to good circuit layout in these 12 fact-filled pages. Write for free copy today!

RIVETT LATHE & GRINDER, Inc.
Dept. MD-2 Brighton 35, Boston, Massachusetts

REPRESENTATIVES IN ALL PRINCIPAL CITIES

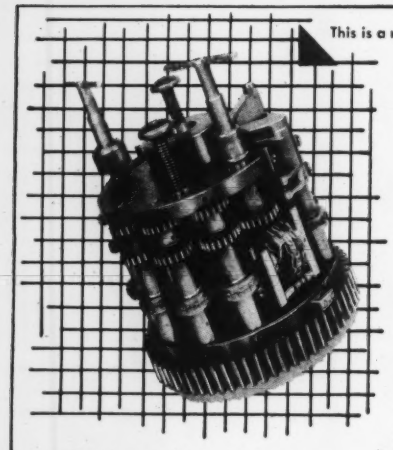
RIVETT furnishes a complete power package

AIR AND HYDRAULIC — VALVES, CYLINDERS, POWER UNITS

Member—National Fluid Power Association

—ITEM 265—
For More Information Circle Item Number on Yellow Card—page 19

This is a numbering head used in printing accurate steel tapes.



Four reasons why BOEHME CRAFTSMANSHIP is Specified

EXPERIENCE
More than 38 years experience in design and manufacture of finest precision products.

RESEARCH
Capable mechanical, electrical and electronic engineering and research staffs.

PRECISION & PRODUCTION
Efficient manufacturing facilities for precision models and quality production in any quantity.

HIGHEST STANDARDS
The highest scientific standards inflexibly applied to every phase of

PRECISION MANUFACTURING—Write today for your free copy of the profusely illustrated brochure which shows graphically how BOEHME'S high standards and prompt, efficient service can be applied to your own specialized needs.

H.O. Boehme, Inc.
Designers and Manufacturers Communication Equipment
Precision Electro-Mechanical Apparatus
915 Broadway · New York 10, N.Y.

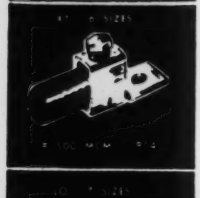
—ITEM 266—

ILSCO CONNECTORS

All these . . . and more . . . for
YOUR BEST CONNECTIONS

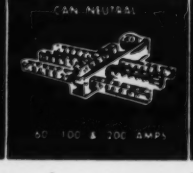
U/L AND CSA TESTED
PURE COPPER
100% CONDUCTIVITY
COOLER OPERATION
HI-RUGGED STRENGTH
RE-USABLE
ALL WIRE SIZES
ECONOMICAL

MAKE YOUR PRODUCT PERFORM BETTER



WRITE FOR
80-PAGE CATALOG

ILSCO CORPORATION
5752 Mariemont Ave.
CINCINNATI 27, OHIO



—ITEM 267—

New Machines

having the extra swing capacity to accommodate a flange or projecting arm on the workpiece. The grinding wheel spindle has Filmatic bearings which are lubricated automatically. Automatic grinding wheel balancing is standard on all models. Controls and levers are grouped at the front of the machine. Hydraulically operated power table traverse provides variable traverse rates from 3 to more than 200 in. per minute. Length of table traverse can be automatically dog controlled to 3/32-in.; hand table traverse can be either 0.200 or $\frac{5}{8}$-in. per revolution. Four spindle speeds range from approximately 100 to 300 rpm. The 6-in. regular and 10-in. light machines are built in 18 and 30-in. lengths. The 10-in. regular and 14-in. light machines are built in five lengths from 18 to 96 in. *Cincinnati Grinders Inc., Cincinnati, O.*

Boring Machine: Automatic vertical boring unit is designed for precision boring, counterboring, facing and chamfering. It maintains tolerances to 0.0001-in. and surface finishes of 10 mu in. rms. The machine has intermittent or continuous automatic cycle and can be automated singly or in a multiple installation. Standard cycle time range is 5 to 80 seconds. Maximum stroke is 4 in.; maximum spindle speed, 8000 rpm. *Wadell Equipment Co., Garwood, N. J.*

Drill Press: Jointed-arm radial drilling machine design incorporates elbow and pedestal pivots equipped with combination radial and thrust bearings to provide accuracy in locating the spindle for each drill bushing. The press has a 1/3-hp, 3600 rpm motor. Double-belt drive and step pulleys provide six spindle speeds from 620 to 12,000 rpm. Spindle travel is $2\frac{1}{2}$ in.; maximum distance from chuck nose to base, 18 in.; radial range, spindle center to column, 24 in. *Hill Machine Co., Rockford, Ill.*

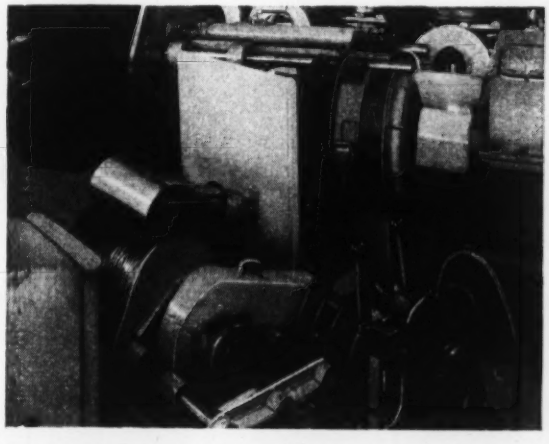
Lapping Machine: Semiautomatic unit finishes hard carbide tool inserts and throw-aways. Manually loaded and unloaded, the machine provides controlled microfinish on tools, with end sections maintained parallel and square to the tool axis. Lapper is equipped with three tool

For More Information Circle Item Number on Yellow Card—page 19

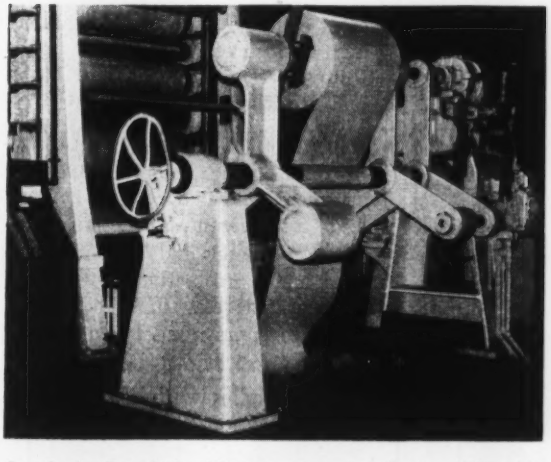
Tension Control Problems?

Dynamatic's Long Experience in Solving Industrial Windup and Unwind Problems will be Valuable to You

DYNAMATIC®



Metal slitter powered by Dynamatic Drives. Adjustable speed liquid cooled coupling used as main drive; Ajusto-Spede® Drives, with constant tension control, wind up the metal strips.



Completely Dynamatic driven paper super-calender. Adjustable speed liquid cooled couplings with Eddy-Current brakes drive the calender rolls and center rewinder. Dynamatic liquid cooled brake provides center unwind hold-back. Co-ordinated controls provide for wide-range adjustment of speed and tension.

Dynamatic Eddy-Current Drives with tension controls are used extensively in the fields of paper, rubber, textiles, ferrous and non-ferrous metals, plastics, and printing.

Combined with associated controls, Dynamatic Eddy-Current Drives provide automatic constant tension as the roll diameter changes on center rewinds and unwinds. Constant tension is maintained over a wide range of material delivery speeds without the use of dancer or follower rolls. Controls may be adjusted for tapered tension to increase or decrease tension automatically as the roll changes diameter.

Multi-range tension or tension adjustment over a wide range is easily accomplished at the operator's station to accommodate materials of various thicknesses or widths. Control modifications are available to provide for inertia compensation and other individual requirements. Dynamatic engineers are available for consultation on your problems.

Bulletins giving detailed information on Dynamatic Tension Control will be sent free at your request.

EATON

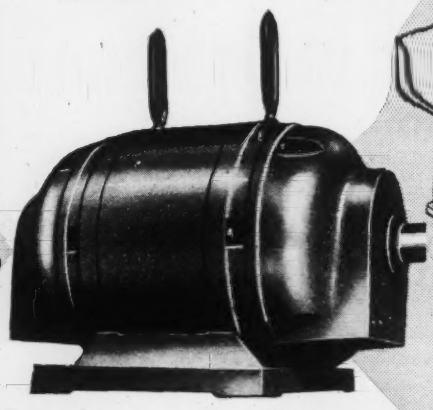
EATON

DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE · KENOSHA, WISCONSIN

—ITEM 268—

VALLEY BALL BEARING MOTORS

Custom Built . . .
NOT Custom Priced!



AIR COOLED

- POLYPHASE, 50 OR 60 CYCLES
- SQUIRREL CAGE INDUCTION
- HIGH TORQUE
- ½ TO 75 H.P.

Cool Running . . . Continuous Service . . .

that's the axiom Valley Motors live up to.

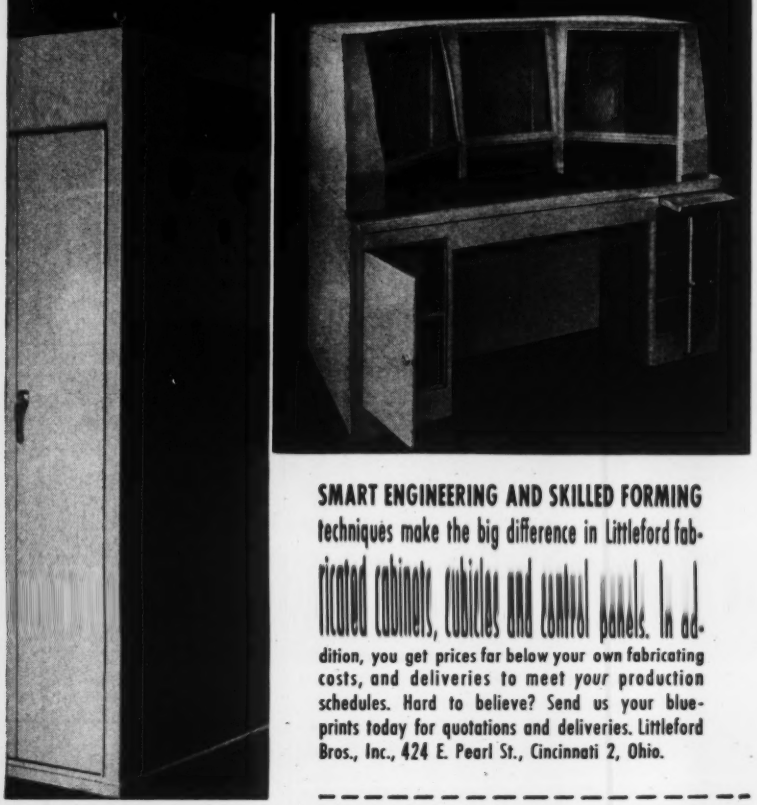
They have been tested and proven in every industry where dependable service and power is a requirement. Remember they are semi-enclosed to assure protection against dripping or splashing liquids, metal chips and abrasive dust.

WRITE FOR COMPLETE INFORMATION

VALLEY
ELECTRIC CORPORATION
4221 Forest Park Blvd. • St. Louis 8, Mo.

—ITEM 269—

LITTLEFORD beautifully fabricated low cost cabinets and control panels



SMART ENGINEERING AND SKILLED FORMING techniques make the big difference in Littleford fabricated cabinets, cubicles and control panels. In addition, you get prices far below your own fabricating costs, and deliveries to meet *your* production schedules. Hard to believe? Send us your blueprints today for quotations and deliveries. Littleford Bros., Inc., 424 E. Pearl St., Cincinnati 2, Ohio.

—ITEM 270—

New Machines

holders for triangular, round and square inserts, one charge of abrasive and loading fixture. It requires 18 x 24 in. bench space and operates on 110 v ac. *Empire Corp., Milwaukee, Wis.*

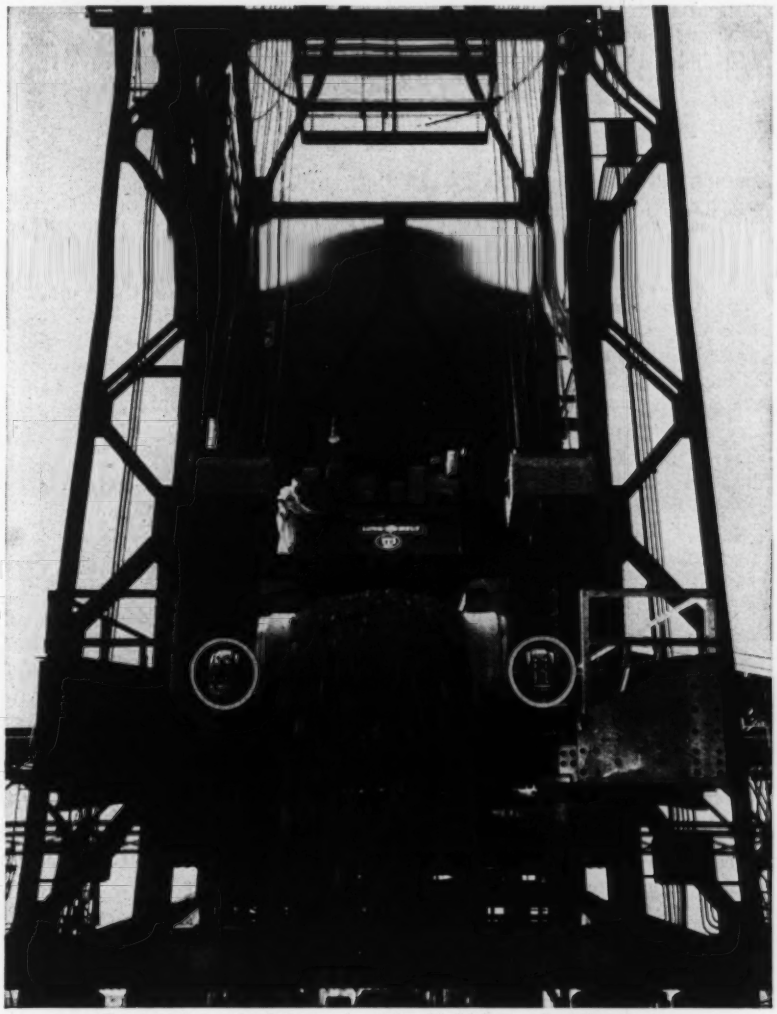
Cut-Off Machine: Model M-35-A metal cut-off machine cuts ferrous and nonferrous materials at less than 4 seconds per sq in. The machine has an adjustable swivel head for angle cutting up to 45 deg left or right. Abrasive wheels for ferrous cutting and steel saw blades for nonferrous cutting are available in 12 or 14-in. sizes. Maximum ferrous capacity is 1½ in. in solids and 2½ in. in standard pipe and structurals. Nonferrous capacity is 2½ in. in solids and 3 in. in tubing and extrusions. The machine has a 1-in. arbor and is powered by a 3½ hp geared-head-induction type motor, and requires floor space of 30 x 40 in. *Stone Machinery Co. Inc., Manlius, N. Y.*

Processing

Induction Heaters: Electronic induction heaters are available in 16 models with output ratings from 7½ to 40 kw for brazing, soldering, surface hardening and annealing. Each model is offered with combinations of thyratron power control, built-in output transformer or tapped-tank coil. Heaters have dustproof, welded steel cabinets and separate aluminum enclosures for oscillator units. Voltage regulation of oscillator and rectifier tube filaments maintains voltage within ± 3 per cent of rated value. Panel control instruments include plate-current and grid-current ammeters, filament voltmeter and tube filament hour meter. Protective devices such as overload relay in high voltage dc plate supply and fused control circuit are provided. Design of the units complies with FCC regulations. *General Electric Co., Industrial Heating Dept., Schenectady, N. Y.*

Sewing Machines: Models 145-146 one or two-needle, high-speed flatbed machines are designed for use with canvas, plastic goods, leather, upholstered furniture, work clothing, mops, etc. Compound feed and alternating pressers

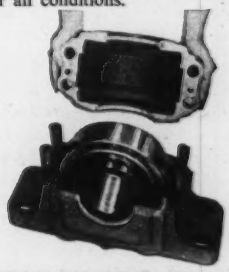
MORE FACTS on why more and more leading manufacturers choose Link-Belt bearings



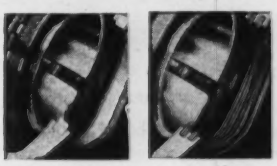
Constant, heavy loads as produced by this high-capacity belt conveyor call for life-long alignment as built into Link-Belt roller bearing blocks.

SELF-ALIGNING ROLLER BEARING IS SELF-

contained and adjusted at the factory, needs no shims or alignment rings at installation. Design assures free rolling under all conditions.



TWO-PIECE HOUSING facilitates installation, inspection and disassembly. Both base and cap are machined as a unit for perfect match. The cap is doweled to the base for proper positioning.



CHOICE OF SEALS. Left, contact-type felt seals for grease lubrication and dirty conditions—right, spiral labyrinth steel seals for oil or grease lubrication and heat conditions.

Husky bearings in husky housings

--the choice for industry's big loads and toughest applications

BRING on your sudden loads and impacts, shaft deflection and misalignment. A heavy-duty, high-capacity Link-Belt self-aligning roller bearing takes such punishment in stride . . . adjusts immediately in all directions . . . delivers a high load at relatively moderate cost.

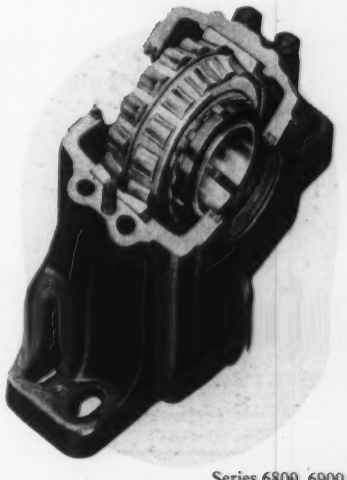
This simple, economical, easy-to-install "package" incorporates the popular Link-Belt self-aligning roller bearing in a durable cast iron housing with provision for lubrication. It's completely sealed to prevent entrance of dirt or loss of lubricant. The self-aligning roller bearings have internationally standardized boundary dimensions and are available everywhere.

For all your bearing needs, look to industry's most complete line of ball and roller bearing blocks. At any of 40 Link-Belt offices, you can get a copy of data Book 2550.

13,991-A

LINK-BELT

Ball and Roller Bearings



Series 6800, 6900, 7800, 7900 roller bearing blocks

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

Whether we

"NEED IT OR NOT"

Frank Sorensen, Jr.

TREASURER, THE CINCINNATI GEAR CO.

In one way we're a little like the old-timer who religiously took a bath every Saturday—whether he 'needed it or not.' We take somewhat the same attitude towards the replacement of our gear manufacturing equipment. We purchase new equipment and tools and retire old machines on a regular calendar basis, even though the old ones may seem adequate for further use. It is all too easy to slip into the habit of putting off purchase of a new unit because the old one still has "lots of use left in it," or is still "relatively" efficient. By prodding ourselves into the purchase of new equipment on a 'schedule' we have avoided this pitfall, and today we have as modern and efficient gear manufacturing facilities as any in the industry. Even our factory buildings (have you ever seen our plant?) reflect this constant striving for the better and the more efficient—for our present plant, built in 1942, replaced a plant that then was a relatively modern installation.

Just as the fellow who took the Saturday night bath was not out of step with the world 50 or 75 years ago, neither was the firm who bought their production machinery "to last." Today, however, the march of technological progress has become so fast and so relentless that we cannot afford to be content with what we have; an aggressive modernization policy is a *must*. We've built up a reputation for producing the best in custom gears, and for producing them efficiently—and we intend to keep that reputation in years to come.

THE CINCINNATI GEAR CO.

CINCINNATI 27, OHIO

"Gears—Good Gears Only"

New Machines

make possible sewing on materials with rough, adhesive or glossy surfaces, and on multiple plies of material to $\frac{5}{8}$-in. thickness. Design of the machine permits its use with synthetic fiber threads. Maximum speed is 3000 stitches per minute. Gear-driven motor is rated $\frac{1}{3}$ or $\frac{1}{2}$-hp. Gears are sealed in lubricant casings. Machines are available in four models for sewing materials ranging from very fine to very heavy. Models for heavy sewing operations have a built-in safety clutch. All models have gear-driven rotary hooks, sliding link take-up and stitch length regulator for sewing forward and reverse. *Pfaff Industrial Sewing Machine Corp., East Orange, N. J.*

Marking Machine: Model 25AF semiautomatic unit is designed for marking flat articles such as tile squares, panels, flat boxes, abrasive wheels and container lids. Manually loaded, the machine holds the workpiece during the marking operation and then releases it to a conveyor. It prints variable detail or complete legend at speeds up to 75 imprints per minute. Type can be changed quickly. Maximum imprint area is from $2\frac{3}{4}$ x 9 in. to 5 x 11 in., depending upon whether master plates, typebars or rubber plates are used. *Markem Machine Co., Keene, N. H.*

Electric Furnaces: Thermocal furnaces are designed for high-temperature use such as heat treating of metal and glass, hardening, annealing, drawing, tempering, stress relieving and silver soldering. Heater components are completely set in refractory plates. Insulation provides high thermal efficiency and low exterior wall temperature. Furnaces are equipped with pyrometer or automatic control and pyrometer. An air scoop is provided to direct hot gases and fumes to the rear of the furnace. Design of the door permits the operator to open it without facing the heat chamber. Six models are available with inside dimensions from 4 x 4 x 4 to $8\frac{1}{2}$ x $8\frac{1}{2}$ x 17 in. All models operate at temperatures to 2300 F intermittent and 2200 F continuous duty on 115 to 220 v ac, 6 to 15 amp. *Auto-Control Laboratories, Culver City, Calif.*

how do you handle it?

PUMP IT with a VIKING

Most of the nationally known companies pump many sticky liquids with P-O-S-I-T-I-V-E VIKING ROTARY PUMPS.

The Viking "gear-within-a-gear" action and port designs allow such material to readily enter the pump. The non-slip action of the gears forces the liquid out in a steady volume.

Capacities 2/3 to 1050 GPM. 750 cataloged models. Thousands of special designs.

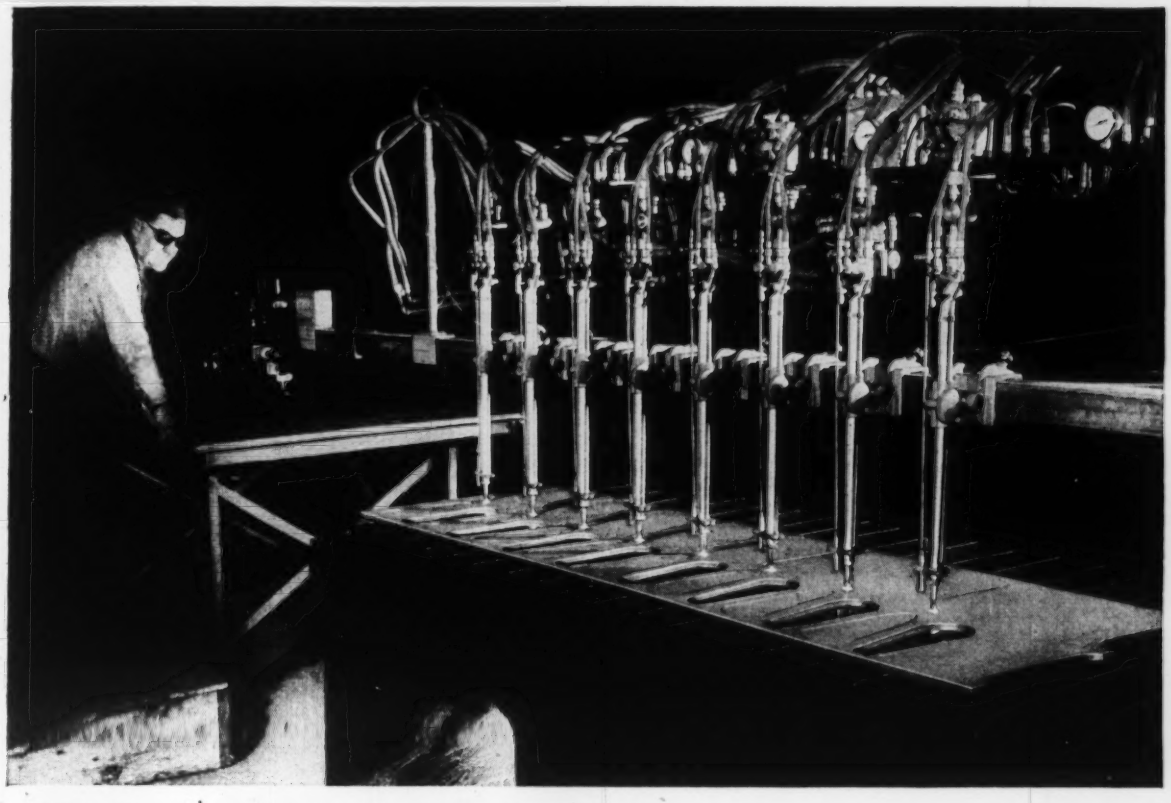
Investigate today the smooth, even flow of Vikings handling either viscous or thin liquids. To start, ask for bulletin series 565 h.

VIKING PUMP COMPANY

Cedar Falls, Iowa, U.S.A. In Canada, it's "ROTO-KING" pumps

THE ORIGINAL "GEAR-WITHIN-A-GEAR" ROTARY PUMP

—ITEM 273—



Many hands make light work...

...with unerring accuracy

Smoothly, the oxyacetylene torch severs and shapes steel plate with unerring accuracy. This universally accepted method of separating metal—machine gas cutting—has advanced in giant steps since torch cutting was introduced. It is impossible to enumerate the many benefits that modern cutting and welding practices have given the metalworking industry. Inevitably even greater services shall be rendered.

Today's complex production requirements demand machines of extensive range and extreme versatility. Which is the *right* Airco shape cutting machine for you?

- **Airco #50 Travograph.** Track-mounted for unlimited range, this unit shape cuts up to eight identical parts within a full 12' circle. The cutting torches conform exactly to the movement of an electronic, manual, magnetic, or spindle tracer.
- **Airco #6B Oxygraph.** (Illustrated) This stationary machine shape cuts within a 29'-9½" x 6'-4½" area. It operates on the pantograph principle (pioneered by Airco) mounting up to 8 torches.
- **Airco #48 Duograph.** Designed for the smaller metal fabricating shop, the Duograph has a rectangular cutting range of 4' by any length.

Other Airco machine gas cutting units include the Monograph, Radiograph, and new Camograph. Details on each are fully covered in individual bulletins. Write today.

AIRCO®

AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated, New York 17, N. Y.

Offices and dealers in most principal cities

On the west coast — Air Reduction Pacific Company

Internationally — Airco Company International

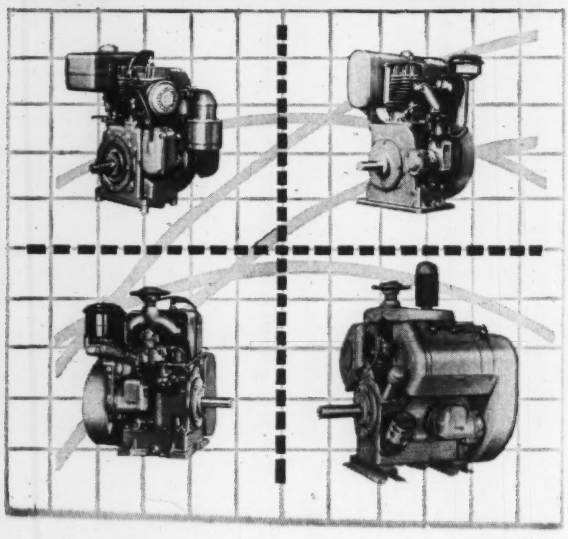
In Cuba — Cuban Air Products Corporation

In Canada — Air Reduction Canada Limited

Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** — industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** — carbon dioxide, liquid-solid ("DRY-ICE") • **OHIO** — medical gases and hospital equipment • **NATIONAL CARBIDE** — pipeline acetylene and calcium carbide • **COLTON** — polyvinyl acetates, alcohols, and other synthetic resins.

—ITEM 274—

WISCONSIN
Heavy-Duty *Air-Cooled* ENGINES
offer the Solution to YOUR POWER PROBLEM



Next to the basic machine itself, one of your major problems, quite obviously, is to select and specify a power component that matches both the machine and the work it is to do . . . *most advantageously.* Wisconsin Heavy-Duty Air-Cooled Engines merit your critical and serious consideration because:

• Every Wisconsin Engine is of HEAVY-DUTY design and construction in all details . . . with the inbuilt stamina to *take it* under all operating conditions, in any climate, at all temperatures from extreme sub-zero to 140° F.

• The Wisconsin lines provide the most complete power selectivity to fit both the machine and the job . . . 12 different models in 4-cycle single cylinder, 2- and V-type 4-cylinder types, in a power range from 3 to 36 hp.

• Servicing of your equipment will be safeguarded by more than 2000 authorized Wisconsin Engine distributors and approved service stations in the United States and Canada.

• In world markets your Wisconsin-powered equipment will be supported by authorized Wisconsin Engine distributors and dealers in 82 countries, carrying service parts and replacement engines.

We will be glad to co-operate with you in adapting Wisconsin Heavy-Duty Air-Cooled Engines to your original equipment *most advantageously.* Tell us about your power problem. Specification bulletins available on all Wisconsin Engines.

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 46, WISCONSIN

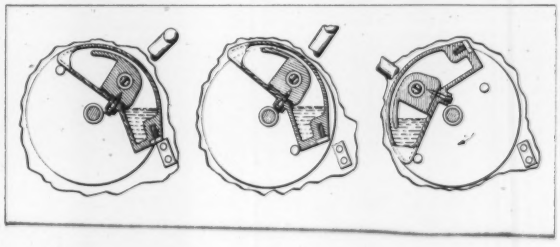
A 8702-½A

—ITEM 275—

NOTEWORTHY Patents

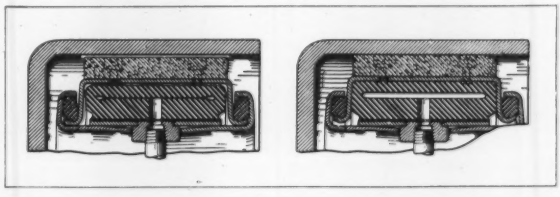
Automatic Rotation Control

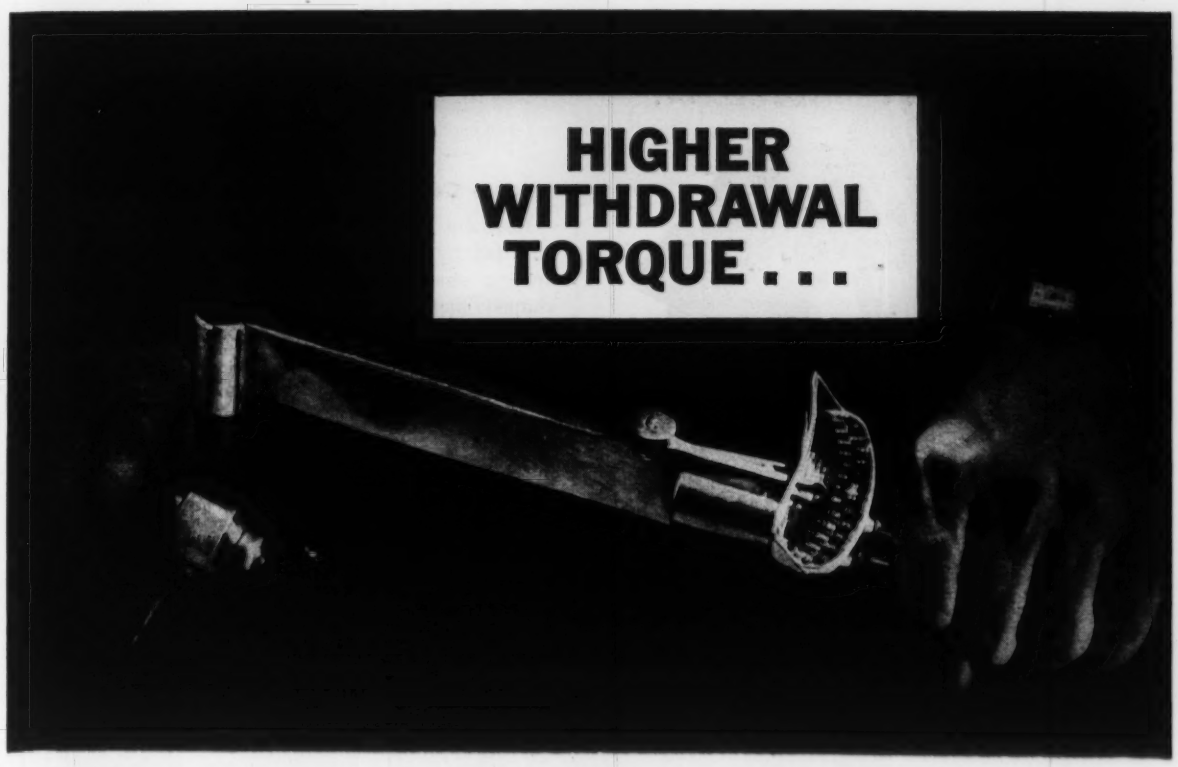
Angular positioning of a rotatable shaft at a predetermined point is accomplished by an assembly having an oscillating member fixed to the shaft. At one point of rotation, the oscillating part strikes an arresting stop. When the shaft stops, a quantity of mercury flows from one of two chambers within the oscillating member into the other chamber, causing the member to become unbalanced. Slight reverse rotation will then release the member from the arresting stop, permitting the shaft to again rotate through the predetermined angle. Valves may be used to restrict the flow of mercury between the chambers to effect a time delay in producing or relieving the unbalanced condition. In this way, the unit may be adapted to varying speeds of rotation. *Patent* 2,708,375 *assigned to Towlsaver Inc. by J. C. Layton and R. Shaffer.*



Pneumatic Clutch

Large torques may be transmitted by means of a heavy-duty clutch design. Actuated by air, gas or hydraulic pressure, the clutch consists of a series of rubber tubes surrounding an inner cylinder that is attached to the drive shaft. As the rubber tubes are inflated, friction pads around the outer circumference of the cylinder engage the inner surface of an outer driven cylinder and a series of rubber rings placed between steel bands around each tube are compressed. When the tubes are deflated, the spring action of the rubber rings forces the friction pads out of engagement with the driven cylinder. Thus, centrifugal force will not tend to hold the clutch in engagement. Vibration and surge in the drive



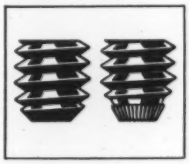


Greater resistance to removal holds Allenpoints tighter in your products

Tests prove that ALLENPOINT Set Screws have 50% HIGHER WITHDRAWAL TORQUE than serrated point set screws

HIGHER WITHDRAWAL TORQUE

WITH ALLENPOINTS! In ¼" x ¼" sizes, tightened to shear point of key, Allenpoints required 75 inch-pounds removal torque. Serrated point set screws gave up their hold at only 50 inch-pounds removal torque.



ONE MORE FULL THREAD WITH ALLENPOINTS! Compare, and you'll find that Allenpoints have *one more full thread* than same size serrated point set screws. That means greater holding power, especially in the much-used "square" sizes.

DEEPER, CLEANER SOCKETS WITH ALLENPOINTS! Allenpoint sockets are *"pressur-formd"* to preserve the long fibers of the steel uncut throughout the *entire* length of the screw. This makes a deep socket of maximum strength, in which the key seats with great exactness.

Specify ALLENPOINTS for far greater *holding* power — the kind of fastenings that "stay put". Genuine Allenpoints and other Allen fasteners are available from your Industrial Distributor — standard items immediately, special items very promptly. Write for full information.

You want maximum holding power from every set screw in your product. Here's why you'll get that from

ALLENPOINT ○ Set Screws: Allenpoints and serrated point set screws were recently compared in laboratory tests. They were the kind of tests you'd make in your own plant — random samples of each were chosen from regular stock boxes from distributors' shelves.

In each test, keys were tightened right up to the shear point — maximum tightening point for any set screw. In each test, 50% HIGHER WITHDRAWAL TORQUE was required to release the ALLENPOINT ○ Set Screws.

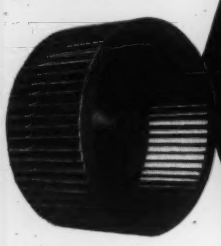
Translated into your own product, this means more dependable fastening with ALLENPOINTS.

—ITEM 276—

Specify GARDEN CITY FANS!

Standard Steel Plate Exhaustor

Design B Multiblade (Forward Curved)



There's a DEPENDABLE FAN for every need

Does your problem involve efficient movement of air? Garden City can help you. For over 75 years they have maintained leadership in the industrial fan field. Three of the many reasons for their superiority: heavier construction, more advanced design, lower maintenance cost. Garden City's high temperature fans (850 to 1650°) are constructed of finest heavy gauge nickel-alloy steels. The radial, forward and backward curved wheels are abrasion and corrosion resistant to a high degree.

Garden City's air cooled shafts on their heat fans increase bearing life. Consequently, the bearings remain maintenance-free longer.

Send your O.E.M. specifications to Garden City's engineers. Their experience may be of help.

Write today for free brochure giving full information.

GARDEN CITY FAN COMPANY
ESTABLISHED 1879

332 S. Michigan Ave.
Chicago 4, Illinois
Dept. G

Representatives in Principal Cities

• Fans for Industry • Backward Curve • Forward Curve
• Material Handling • Radial Bladed • Small Exhaust

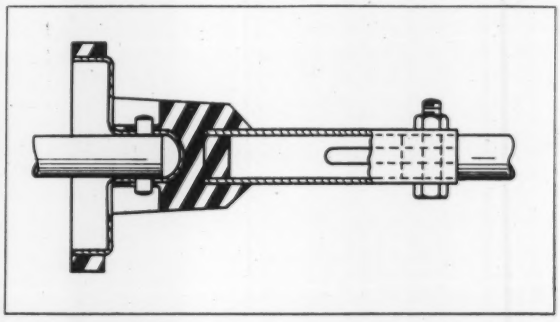
—ITEM 277—

Noteworthy Patents

system are also reduced by the inherent resilience of the pneumatic coupling. *Patent* 2,708,994 *assigned to General Tire and Rubber Co. by H. T. Kraft.*

Flexible Coupling

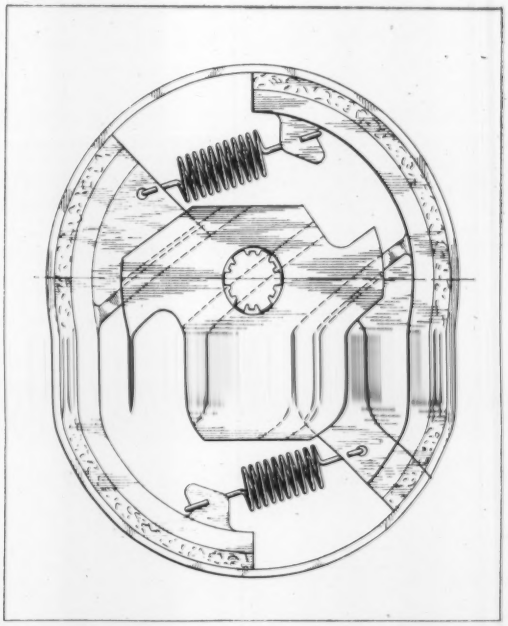
Resilient connection of two rotating shafts is afforded by a three-piece coupling. Fastened to the driving shaft is a metal tubular member. A cup-shaped metal member is fastened to the driven



shaft. Bonded to both the driving and driven shaft connectors is an intermediate rubber element. Notches provided in the cup-shaped metal member permit the rubber to be molded and bonded to it in one operation. *Patent* 2,708,351 *assigned to Lord Mfg. Co. by J. R. Gensheimer.*

Centrifugal Clutch

Driven centrifugal clutch shoes are mounted to slide back and forth through a tongue and groove arrangement with the rotating hub. Helical springs hold the clutch shoes out of driving engagement when the clutch is stationary. As the shoes are rotated, centrifugal force slides them outward in the slots to engage the driven member. No rigid connection is necessary in the hub and shoe assembly. *Patent* 2,707,542 *assigned to Elgin Sweeper Co. by C. H. Thompson.*



KEPS

TIME RECORD SHEET

Backlog getting bigger... how do we speed our production??

Assembly people are having trouble with lock washers and nuts... Keep dropping 'em or "forgetting" 'em

SAY! What about KEPS? Nut and lock washer are pre-assembled mechanically before they reach the line!

The lock washer can't drop off but rotates freely

The SHAKEPROOF® Lock Washer has powerful twisted teeth that bite deep, give positive locking action

Vibration will NEVER work KEPS loose!

KEPS... save time, improve product quality and cut costs!

SHAKEPROOF SAMPLER

SHAKEPROOF

"Fastening Headquarters"®

St. Charles Road, Elgin Illinois • Offices in Principal Cities
In Canada: Canada Illinois Tools Limited, Toronto, Ontario

SHAKEPROOF
FASTEX

DIVISIONS OF ILLINOIS TOOL WORKS
World's Broadest Line of Mass-Assembly Fastenings

K160
6.6 H.P.
Full Power

KOHLER ENGINES

4-CYCLE • AIR-COOLED

A Quality Engine for Quality Equipment

Short Stroke

- Less Friction and Wear
- More Power
- Longer Life

Easy Starting

K90.....2.5 to 3.6 H.P.
K160.....3.6 to 6.6 H.P.
K330.....7 to 11.8 H.P.
K660.....12 to 26 H.P.

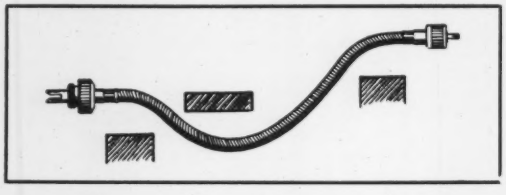
Kohler Co., Kohler, Wisconsin
Established 1873

KOHLER OF KOHLER

PLUMBING FIXTURES • HEATING EQUIPMENT • ELECTRIC PLANTS
AIR-COOLED ENGINES • PRECISION CONTROLS

—ITEM 279—

STRENGTH AND FLEXIBILITY



Recent advances in manufacturing techniques have made possible the production of flexible shafts able to handle loads greatly exceeding those of some years ago when flexible shafting was largely confined to the handling of small loads. This was due to the size of the flexible cable having to be enlarged excessively in ratio to the load applied.

For example, a flexible shaft which will carry a load of 55 lb. inches will require a flexible cable with a .187" diameter. This cable has a torsional deflection of only 4.7° and may be bent into a minimum radius of 3" while made to rotate in either a clockwise or counter clockwise direction when being viewed from the driven end. Previously, this same load of 55 lb. inches would have required a much more cumbersome and more expensive cable which would have lost its flexibility with the increase of the cable diameter.

Flexible shafting for use in industry offers distinct advantages in alignment, the main advantage being its ability to transmit power over, under and around obstacles without the use of costly and complicated gearing. It responds immediately to the drive power and may function in a continuous or intermittent operation. Flexible shafts may be composed of either power drive cable for rotation in either a clockwise or counter clockwise direction, or they may be composed of remote control cable which provides for rotation both clockwise and counter clockwise.

The F. W. Stewart Corporation is prepared to manufacture complete flexible shaft assemblies to your specifications which will permit easy and economical incorporation of flexible shafts into your designs.

Send for further details. F. W. Stewart Corporation, A Subsidiary of the S. S. White Dental Mfg. Co., 4311—13 Ravenswood Avenue, Chicago 13, Illinois.

—ITEM 280—

READY NOW!

These 4 Brand New Patterns for your 1957 Products

40 other standard patterns also available

RIGID-tex

the modern metal for the products of tomorrow

Sales experience gained today stresses the importance of beauty in the products of tomorrow. RIGID-tex Metal has sparkling beauty plus functional mar resistance. Available in stainless steel, aluminum . . . in fact all metals — all finishes.

See Sweet's Design File 1a/Ri or write us for information.

IT'S RIGIDIZED®

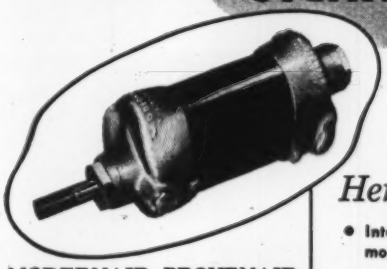
RIGIDIZED METALS CORP.
6932 OHIO STREET BUFFALO 2, N. Y.
Sales Representatives in Principal Cities

—ITEM 281—

Simplest to Install and Service!

Modernair Trademark

PROVENAIR
Air and Hydraulic
CYLINDERS

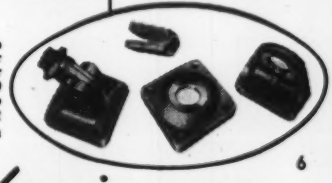


Here's why:

- Interchangeable mountings
- Heads rotate 360°
- Standard "O" ring seals throughout
- Corrosion resistant

MODERNAIR PROVENAIR cylinders are available in 2", 3", 4" and 6" bore sizes, any practical stroke length, cushion or non-cushion types. Operate to 400 p.s.i. in 2" and 3" bores, 200 p.s.i. in 4" and 6".

Why gamble when you can get PROVENAIR—the pioneer corrosion-resistant cylinder backed by more than 10 years successful use? Write today for new MODERNAIR catalog—most complete in industry!



6

Modernair TRADEMARK **CORPORATION**

Dept. E-2 400 PREDA ST. • SAN LEANDRO, CALIF.
Member of National Fluid Power Association

—ITEM 282—

---

to help you solve your spring design problems

"MECHANICAL SPRINGS"

by A. M. Wahl

THOROUGH DISCUSSION OF FUNDAMENTAL PRINCIPLES . . . PRACTICAL FORMULAS FOR DESIGN . . . AUTHORITATIVE INFORMATION ON SPRING APPLICATIONS . . . IN 435 PAGES FULLY ILLUSTRATED WITH DETAILED DRAWINGS.

Thousands of design engineers have discovered "MECHANICAL SPRINGS" by A. M. Wahl . . . it has become a practical aid to spring design in hundreds of design libraries.

It contains the kind of information that enables preliminary calculations to be made on the design of all types of springs: helical, disk, Belleville, flat, leaf, torsion, spiral and volute.

And no matter what your problem . . . working stress . . . fatigue . . . buckling . . . or just plain maximum efficiency, you will find that "MECHANICAL SPRINGS" can reduce the "guesswork" as well as save you time and materials.
Use the form below and get yours today!

Book Department
Penton Publishing Co.
Penton Building
Cleveland 13, Ohio

Send me____copies of "MECHANICAL SPRINGS" at $6.00 per copy.
☐ Remittance enclosed in which case book will be sent postpaid
☐ Please bill me ☐ C. O. D.

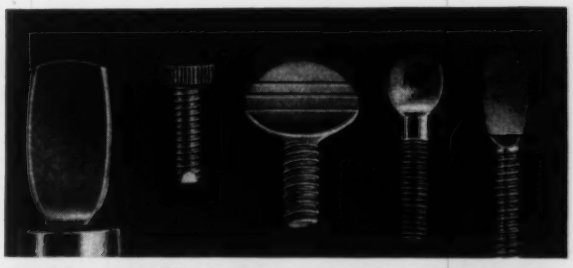
NAME _____ TITLE _____

COMPANY _____

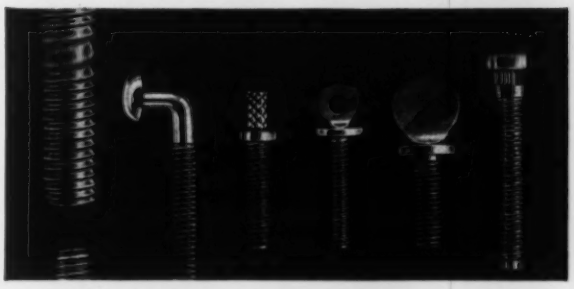
ADDRESS _____

CITY _____ ZONE ____ STATE _____

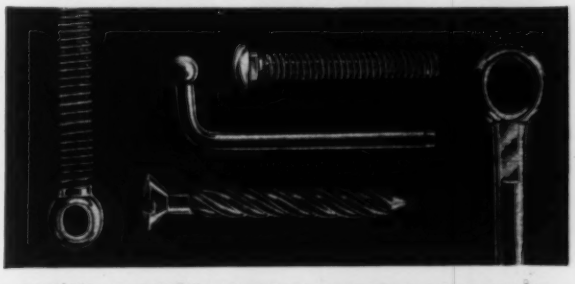
(Add 3% to orders for delivery in Ohio to cover State Sales Tax.)



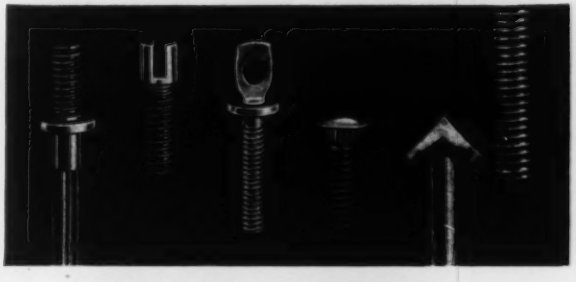
YOU CAN'T BEAT COLD FORMING



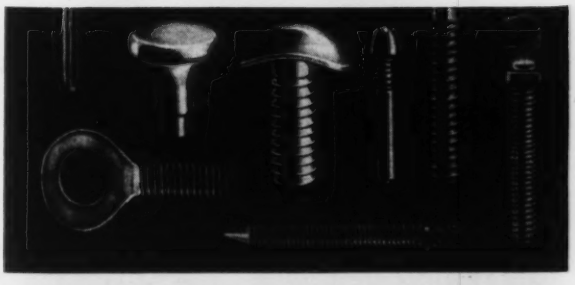
FOR PARTS LIKE THESE—AND



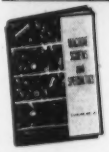
YOU CAN'T BEAT PROGRESSIVE



FOR COLD FORMING . . .



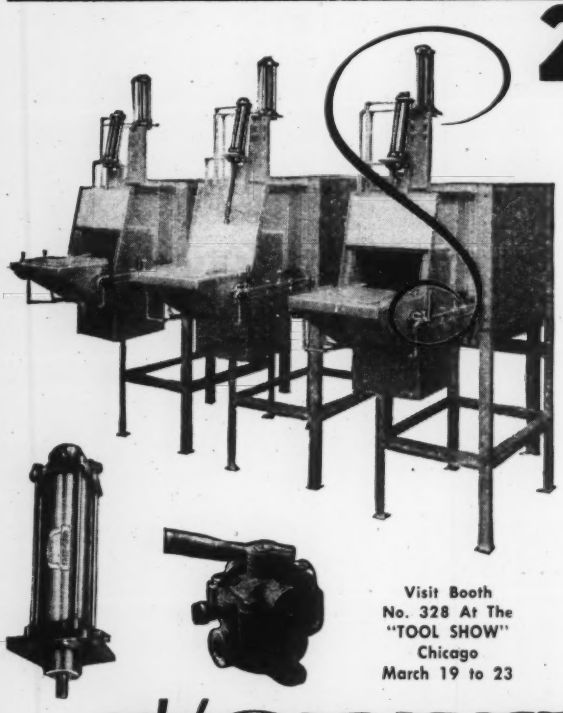
MACHINE SCREWS AND SPECIAL FASTENERS ARE OUR BUSINESS . . . INCLUDING SQUARE AND HEXAGON MACHINE SCREW NUTS



WRITE FOR OUR CATALOG

THE PROGRESSIVE MANUFACTURING COMPANY
52 Norwood St., Torrington, Conn.

—ITEM 283—



20 YEARS Trouble-Free Service on Hevi Duty Electric Furnaces

Hevi Duty Electric Co., Milwaukee, builder of Electric Heat Treating Furnaces, has found that NOPAK Cylinders and Valves can be depended upon for the many years of trouble-free service which users expect of Hevi Duty Furnaces. Not once in 20 years has a Hevi Duty customer returned a NOPAK Component for replacement.

The furnaces pictured are used to harden steel dies employed in the manufacture of jewelry. Outer doors, inner partitions and conveyor trays . . . all are actuated by NOPAK Cylinders controlled by externally mounted NOPAK Valves.

Another reason why Hevi Duty specifies NOPAK Products is the simplicity and ease of their installation . . . an important factor in cutting assembly costs.

Examples showing how NOPAK Products are used in other types of machinery and equipment are described in the NOPAK Application Manual. Ask your NOPAK representative, or write for your copy.

Visit Booth
No. 328 At The
"TOOL SHOW"
Chicago
March 19 to 23

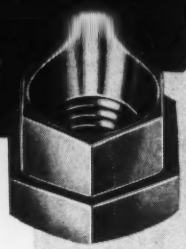
NOPAK
® VALVES AND CYLINDERS
DESIGNED for AIR and HYDRAULIC SERVICE

GALLAND-HENNING NOPAK DIVISION
2752 SOUTH 31ST STREET • MILWAUKEE 46, WISCONSIN

A 8633-½-H

—ITEM 284—

use these
GRIPCO CLINCH NUTS
with the exclusive
hex on hex
feature



for "fixed" fastenings for "hard-to-reach" or blind assemblies. They wear longer, hold tighter, give greater customer satisfaction.

See how leading appliance manufacturers get lower cost fasteners into inaccessible places.

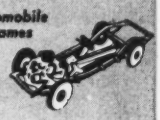
Gripco Clinch Nuts can be either clinched solid for a rigid application or staked in with a six point staking punch to give a floating effect. This floating effect takes care of misalignment and makes the application of the bolt easier. Gripco clinch nuts can be clinched or staked with stationary or portable hydraulic or air equipment. Details on request. Write for samples and data sheet.

Typical Applications

Automatic Washer for leg leveling and crating on all appliances

Tractor Seats

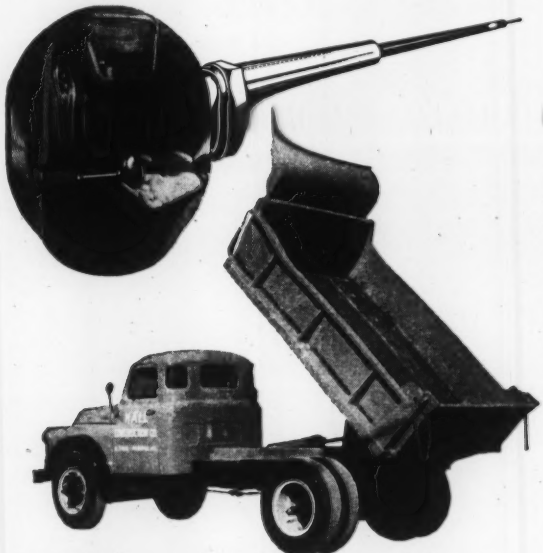
Power Lawn Mowers


Automobile Frames

GRIP NUT COMPANY
310-W S. Michigan Avenue, Chicago 4, Illinois

113

—ITEM 285—



ARENS... *Dependable, Low Cost Remote Controls*

Write for Catalog
40 page Push-Pull Control Catalog. Write for it.

The Heil Co., leading manufacturer of truck bodies, relies on Arens 6-D Heavy Duty Remote Push-Pull Controls to actuate hoist mechanisms. For your remote control application, consider an Arens Control in your design planning. Arens low cost standard controls can give you the benefit of quantity production. We also engineer "specials."

ARENS CONTROLS, INC.
2009 Greenleaf Street • Evanston, Illinois

—ITEM 286—

VULCAN
ELECTRIC HEATING UNITS

On Airplanes

in high altitudes and sub-zero temperatures. Vulcan Electric Heating Units hold lubricants in a liquid state.

They're used also as anticipators in thermostatic control: in guided missiles and in speed indicators.

Vulcan electric heat is helping in many new inventions for both war and peace. To assist in the further development of your ideas, Vulcan heating designers will be glad to join their know-how to yours.

VULCAN ELECTRIC CO.
DANVERS 6, MASS.

Makers of Vulcan Electric Soldering Tools, Electric Solder Pots, Electric Glue Pots, Electric Branding Irons and Electric Heating Units.

See 8-page Vulcan catalog in Sweet's Product Design File for 1955

—ITEM 287—

New MARCO
TYPE Y5 SHADED POLE MOTOR

1/25 to 1/4 h.p.

- Higher Efficiency
- Better Stability
- Cooler Operation

LOW in COST

• This new, large diameter (5-1/2"), more powerful motor has all the features of the famous Marco Motors used in hundreds of thousands of air conditioning units — in fans, blowers and furnaces.

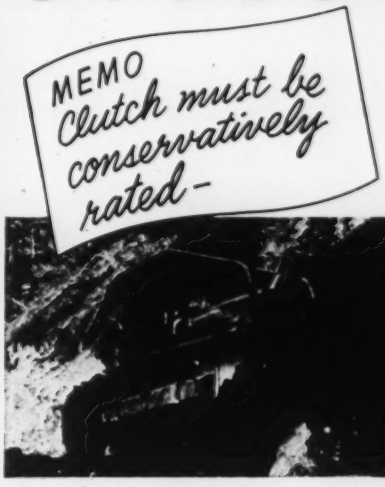
Power up to 1/4 h.p. can be supplied — or — in the new "wafer thin" design (as short as 2-1/2 inches) 1/15th horsepower.

Get the facts on this motor today!

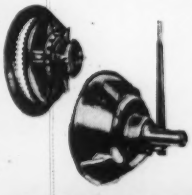
MARCO INDUSTRIES, INC.
3rd & Franklin Sts., Womelsdorf, Pa.

—ITEM 288—

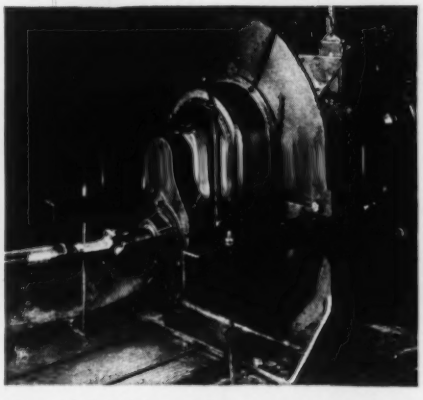
ROCKFORD



ROCKFORD POWER TAKE-OFFS are designed for generous overload capacity, within the fields of service recommended by Rockford Clutch engineers.



ROCKFORD POWER TAKE-OFFS Are Heavy Duty Tested



Large ROCKFORD clutches, power take-offs and speed reducers are tested for torque, engaging pressure, release, temperature, gear strength, bearing endurance and clutch facing wear on this 400 H.P. diesel powered, electric dynamometer. Let ROCKFORD engineers utilize this machine to improve your heavy-duty power transmission controls.

Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

B. W. ENGINEERING MAKES IT WORK

ENGINEERING B-W PRODUCTION

B. W. PRODUCTION MAKES IT AVAILABLE

ROCKFORD
Clutch Division
BORG-WARNER
311 Catherine St., Rockford, Ill.

CLUTCHES

—ITEM 289—

GEAR PROBLEMS got you down?

Noise? Vibration?
Early Wear? Difficult Design?
Unsatisfactory
machine performance?
High cost?

Get the solution with a *Free, Confidential* *Sier-Bath* GEAR DIAGNOSIS

With today's frequent advances in gear producing and gear testing machinery, making good gears has become as specialized as making ball bearings.

Sier-Bath has helped many leading machine builders with their gear problems. Everyone who has approached us with gear problems has always left minus the problems.

Take advantage of Sier-Bath's unsurpassed experience and facilities in the design and production of your gears. Learn for example, how you can have ground tooth gears at prices comparable to unground gears . . . or cut your costs, if that is your only problem.

Write us your gear problem for diagnosis—or request a Sier-Bath gear specialist to call for discussion at any appointed time, without charge or obligation, on a strictly confidential basis. Usual quantities 12 or more of a kind, except for prototypes.

SIER-BATH PRECISION GEARS

***Sier-Bath* GEAR and PUMP CO., Inc.**

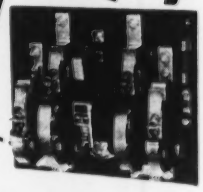
50th Anniversary 9237 Hudson Blvd., North Bergen, N. J. Member A.G.M.A.

Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings

—ITEM 290—

ZENITH

MOST DEPENDABLE CONTACTORS IN THE INDUSTRY



For:

time switches—
motor starters—
lighting—equipment
control—all applications
requiring complete reliability and long service life.

All parts are accessible—readily inspected, easily replaced. Full floating armature permits perfect magnetic seating, silences AC hum.

Contacts are copper to copper. Heavy compression springs assure contact pressure, quick opening. Coil will not overheat in 24-hr. continuous service.

Zenith contactors are made for severe duty. Capacities to 400 amps.

Send for this handy new bulletin

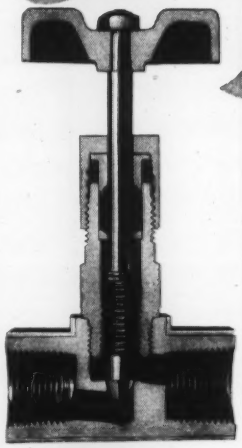
See classified telephone directory for name of local distributor

ZENITH ELECTRIC CO.

149 WEST WALTON STREET • CHICAGO 10, ILLINOIS

—ITEM 291—

Now... the Marsh Needle Valve in 416 Stainless Steel throughout!



All the superior dependability of the Marsh Needle Valve . . . with all the corrosion resistance and durability of 416 Stainless Steel! Guaranteed for working pressure up to 10,000 psi; equally efficient at any lower pressure. Globe and angle patterns with double female connections in ⅛" to 1" size range. Also globe and angle valves with male inlet, female outlet, ¼" and ½" sizes.

For complete details, write for Bulletin No. NV-2.

MARSH INSTRUMENT CO.

Sales Affiliate of Jas. P. Marsh Corp.

Dept. B, Skokie, Illinois

MARSH

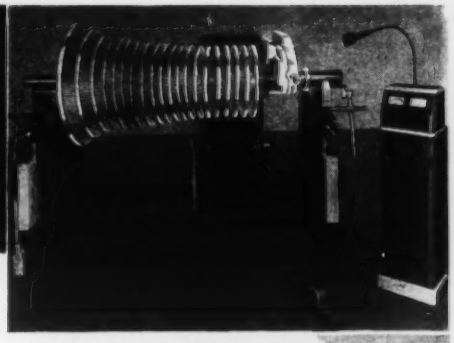
"THE STANDARD OF ACCURACY"

Marsh Instrument & Valve Co. (Can.) Ltd., 8407 103rd St., Edmonton, Alta., Can.

—ITEM 292—

4 OUT OF 5

VIBRATION PROBLEMS ORIGINATE WITH UNBALANCE



NOW Save up to 50%* of your balancer investment ... Eliminate Dynamic and Kinetic unbalance ... with a STEWART-WARNER ELECTRONIC INDUSTRIAL BALANCER

IN PRODUCTION... greatly reduce your manufacturing costs by eliminating rejects caused by rotor unbalance.

FOR MAINTENANCE... reduce your maintenance expense by eliminating down time situations requiring replacement of bearings and shafts, labor, etc., in addition to production loss. Instrumentation will also measure areo-dynamic vibration factors.

STEWART-WARNER electronic industrial balancers are sturdy, compact, extremely accurate and engineered for years of trouble-free service.

Extreme maximum and minimum ranges are engineered into every STEWART-WARNER ELECTRONIC INDUSTRIAL BALANCER. Other makes require more than one machine to attain these capacities.

Stewart-Warner Electronic Industrial Balancers are manufactured and distributed by:

CRADLE and PORTABLE MODELS available

Check These Stewart-Warner Established Capacities:

- ½ lb. to 25,000 lb. weight range
- ½" to over 96" diametral capacity
- .03 in.-oz. Dynamic sensitivity
- Convenient friction belt drive requires no adaptors and eliminates belt wrap-around problems
- Less than 2 minutes set-up time without supervision
- From $3795 including operator training
- 4½" to over 144" length range
- .01 in.-oz. Kinetic sensitivity
- Operating safeguards

The above capacities are established. Should your requirements exceed the above, please write us stating your exact balancing problem.

*No other industrial balancer incorporates so many advanced features, yet the Stewart-Warner sells at approximately 30% less than other advertised industrial balancers.

Write now for FREE brochures with complete information

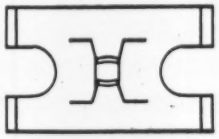
MERRILL *engineering laboratories*

"Industrial Electronic Balance Specialists since 1935" • DEPT. SJ • 1240 LINCOLN STREET • DENVER 3, COLORADO

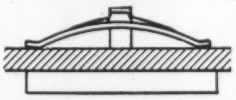
—ITEM 293—

At Last!
A LOW-COST RATTLEPROOF FASTENER

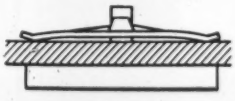
for die-cast Nameplates, Medallions, Grilles, etc.



Four Gripping Teeth
HOLD TIGHT
even on hard or slippery plated studs



Long Spring Arch compensates for wear on parts



Turned-up Ends slide smoothly without damage to surface

Write for free samples, dimensions, prices. State size.

TYPE "H" PUSHNUTS
TRADEMARK

The new Type "H" Pushnuts exert a powerful spring force when assembled which continues to hold parts tight in service, regardless of vibration and wear on assembled parts. In addition, Pushnuts are lower in cost—apply easy and fast with manual or power tool applicators—do not damage studs or seat. Foolproof in assembly—rattleproof in service. Sizes for ¼", 5/32" and ⅛" studs. Choice of plain, parkerized or cadium finishes. Try Pushnuts!

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In Canada:
P. L. Robertson Co., Ltd., Milton, Ont.

—ITEM 294—

INSURE *Proven Quality* with JONES PLUGS AND SOCKETS

P-306-CCT Plug, Cable Clamp in Cap.

Jones Series 300 illustrated. Small Plugs & Sockets for 1001 Uses. Cap or panel mounting.

S-306-AB Socket with Angle Brackets.

- Knife-switch socket contacts phosphor bronze, cadmium plated.
- Bar type Plug contacts brass, cadmium plated, with cross section of 5/32" by 3/64".
- Insulation molded bakelite.
- All Plugs and Sockets polarized.
- Metal Caps, with formed fibre linings.
- Made in two to 33 contacts.
- For 45 volts, 5 amperes. Efficient at much higher ratings where circuit characteristics permit.

Ask for Jones Catalog No. 20 showing complete line of Electrical Connecting Devices, Plugs, Sockets, Terminal Strips. Write or wire today.

Jones
HOWARD B. JONES DIVISION
CINCH MANUFACTURING CORPORATION
SUBSIDIARY OF UNITED-CARR FASTENER CORP.

—ITEM 295—

MECHANICAL DESIGN ENGINEERS

Earthmoving experience, with successful record in design and development of heavy mechanical equipment, crawler tractors, bulldozers, winches and attachments.

Work includes layout and design of heavy machinery for construction and mining.

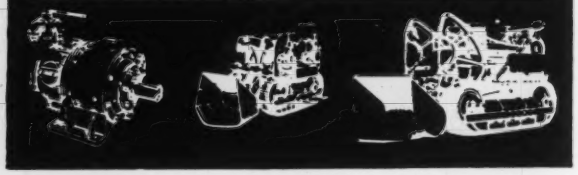
Permanent positions open, for those qualified, with one of the nation's fastest growing heavy machinery manufacturers.

Location—Salt Lake City, Utah—in the mountain West, where you can breathe clean air, and drive from home to work in less than 20 minutes.

Send complete information and photograph to:

The EIMCO Corporation

P. O. Box 300 **Salt Lake City 10, Utah**



—ITEM 296—

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For manufacturer making Bellow Seal Boot (accordion pleated type) used to seal out dirt from moving parts.

Product would make suitable added line for manufacturers representatives calling on Machine Tool Builders.

All replies will be held in strict confidence. For further information reply by letter to:

GARDAN MANUFACTURING CO.

P. O. Box #34 New Castle, Pa.

—ITEM 297—

ENGINEERS
AVAILABLE OR WANTED

WANTED: Engineers—New Product Development. Ingenuity and initiative applied to New Product Development with a growing far-sighted company means progress for the experienced Electrical or Mechanical Engineers who are selected for these choice positions. Experience required in: Mechanical Design. Heat Transfer. Servo Mechanisms. Stress Analysis. Electro-Mechanical Devices. These positions offer an opportunity to grow in the fields of Atomic Power and Automation. Reliance Electric and Engineering Company. 1088 Ivanhoe Road. Cleveland 10. Ohio. Glenville 1-3530. Extension 570.

* * *

WANTED: Mechanical Engineers and Mechanical Draftsmen. Growing company expanding Engineering Division. Opportunity for rapid advancement into management and development work on mechanical parking garages, aircraft hangars, industrial buildings, TV broadcast antenna towers. Liberal benefits including retirement. Moving expenses paid. Write: E. L. Smith, Dresser-Ideco Company, One of the Dresser Industries, 875 Michigan Avenue, Columbus 8, Ohio.

* * *

WANTED: Machine Designer. Man to take charge of and develop machine design section of medium size non-metal manufacturing company. Work involves designing equipment for automating plant. Company currently undergoing extensive research and process development program. Ability to make free hand sketches and concise assembly drawings required. Submit complete resume of education, experience and salary requirement to Employment Manager, P. O. Box 120, New Castle, Pennsylvania.

* * *

WANTED: Mechanical or Structural Design Engineers for immediate, permanent positions in Alliance, Ohio with large, long-established designer and builder of overhead travelling cranes, rolling mills, and other heavy machinery. Excellent salary and benefits. Write, sending complete resume of background and experience to R. J. Fitzgerald, Industrial Relations Division, The Morgan Engineering Company, Alliance, Ohio.

Get yours while the supply lasts!

MACHINE DESIGN'S

"Directory of Materials"

18th Edition

the only one of its kind available anywhere

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MACHINE DESIGN
$1.00 per Copy

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Electronic *Mechanical*

There's room to...

GROW

AT MELPAR

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- Systems Evaluations
- Microwave Technique
- UHF, VHF, or SHF Receivers
- Analog Computers
- Magnetic Tape Handling
- Digital Computers
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Packaging Electronic Equipment

- Pulse Circuitry
- Microwave Filters
- Flight Simulators
- Servomechanisms
- Subminiaturization
- Electro-Mechanical Design
- Small Mechanisms
- Quality Control and Test Engineers

More and more these days you hear top engineers talk about the many growth opportunities at Melpar. With an increasing number of significant electronic projects, an enlarged staff and facilities, Melpar provides many opportunities for professional growth and advancement. Our new laboratory is an engineer's dream come true; a building conceived by and constructed for the ENGINEER – 265,000 sq. ft. of complete engineering facilities.

We are located in Fairfax County of northern Virginia where housing is reasonable and plentiful—whether you desire a private home or an apartment. Although we are in a truly suburban atmosphere, we are only 10 miles from the nation's capital with all its recreational and social advantages. Here you and your family can grow in an environment to match your professional growth.

Send resume to Technical Personnel Representative,

melpar, inc.
A subsidiary of the Westinghouse Air Brake Co.
3000 Arlington Blvd., Dept. MD-17, Falls Church, Va.
11 Galen Street, Watertown, Mass. • 99 First St., Cambridge, Mass.

—ITEM 298—

Chief Product Engineer

To supervise design and development of automatic flow-control valves and devices for refrigeration, air conditioning, heating and general industrial applications. Should have at least 10 years' experience, and have some knowledge of electrical control mechanism.

Must be capable of supervising, leading and inspiring a force of from 12 to 15 engineers and designers in an organization looking forward to constant growth. BSME or BSEE degree or the equivalent in background and experience.

This is an important position with a well-known AAAA company, highly regarded as a leader in the control field. Midwest location in pleasant metropolitan community.

Excellent salary commensurate with background and experience. Write BOX 889, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

POSITIONS ALSO OPEN FOR DESIGN ENGINEERS—
LABORATORY ENGINEERS

—ITEM 299—

MACHINE DESIGN ENGINEERS

You can be SURE

- of professional recognition
- of a successful financial future

AT THE ELECTRONIC TUBE DIVISION OF

Westinghouse

in Elmira, N. Y.

Yes . . . you can count on a friendly and creative atmosphere . . . world-important work . . . where everybody is on "your team", and your talents are tangibly rewarded. You and your family can also count on enjoying the "Elmira" way of life, a great combination of vacation-land facilities and all city advantages.

Openings for:
MECHANICAL DESIGN ENGINEERS, to design automatic machines for production of electronic tubes. 5 to 10 years responsible experience in design of automatic machinery required. Vacuum-tube equipment experience is desirable but not mandatory.

Interviews in your area, or travel expenses paid for interviews in Elmira. Send resume:

R. M. Jarrett
WESTINGHOUSE ELECTRIC CORP.
Electronic Tube Div., P.O. Box 284, Elmira, N.Y.

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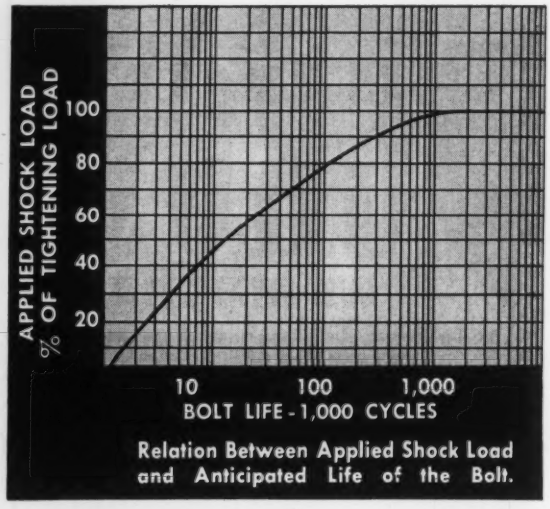

Relation Between Applied Shock Load and Anticipated Life of the Bolt.

factor to be considered, in application of finished hexagon nuts...

Figure 3, page 6 in the Engineering Section of our catalog, "Relation Between Applied Shock Load and the Anticipated Life of the Bolt," is just one of the several factors that are discussed, on pages 3, 4, 5 and 6, in the application of finished hexagon nuts, where highly stressed bolts of special material are required . . . Fourteen topics, concerning the technique in the manufacture and proper installation of our product are covered in this twenty-four page brochure—requests for this literature will be handled promptly . . . . . .

NATIONAL MACHINE PRODUCTS COMPANY

Manufacturer of Standard and Special "12 Pointer and Hexagon Nuts..." "Huglock" and "Marsden" locknuts,

44253 Utica Rd., UTICA, Michigan

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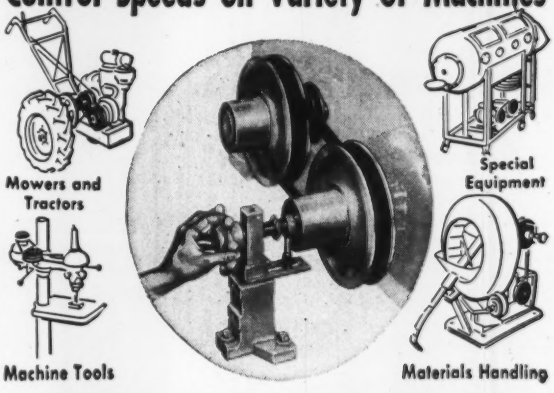
SPEED SELECTOR

VARIABLE PITCH SHEAVES

Control Speeds on Variety of Machines



New! Wide Speed Range! Low Cost Sheaves

Speed Selector Sheaves can give your machines or equipment extra wide-range speed control on fixed centers. Efficient, rugged, simple to use — low in cost! Write for Illustrated Bulletin.

CATALOG FREE! WRITE TODAY

SPEED SELECTOR INC.

120-B NOBLE COURT • CLEVELAND 13, OHIO

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Abart SPEED REDUCERS and GEARS...

famous for long and DEPENDABLE SERVICE

SPEED REDUCERS

Efficient, compact . . . over 75 types and sizes . . . spur, worm and combination.

1/50 to 168 hp. . . . ratios to 10,000 to 1 . . . specials to order.

GEARS

Precision cut to exact specifications from any gear material.

96 pitch to 5/7 D.P. . . . ¼" P.D. to 18" P.D. . . . any type or quantity.

GET ABART'S 96-PAGE POCKET-SIZE CATALOG

ABART GEAR and MACHINE CO.

4821 WEST 16th STREET • CHICAGO 50, ILLINOIS

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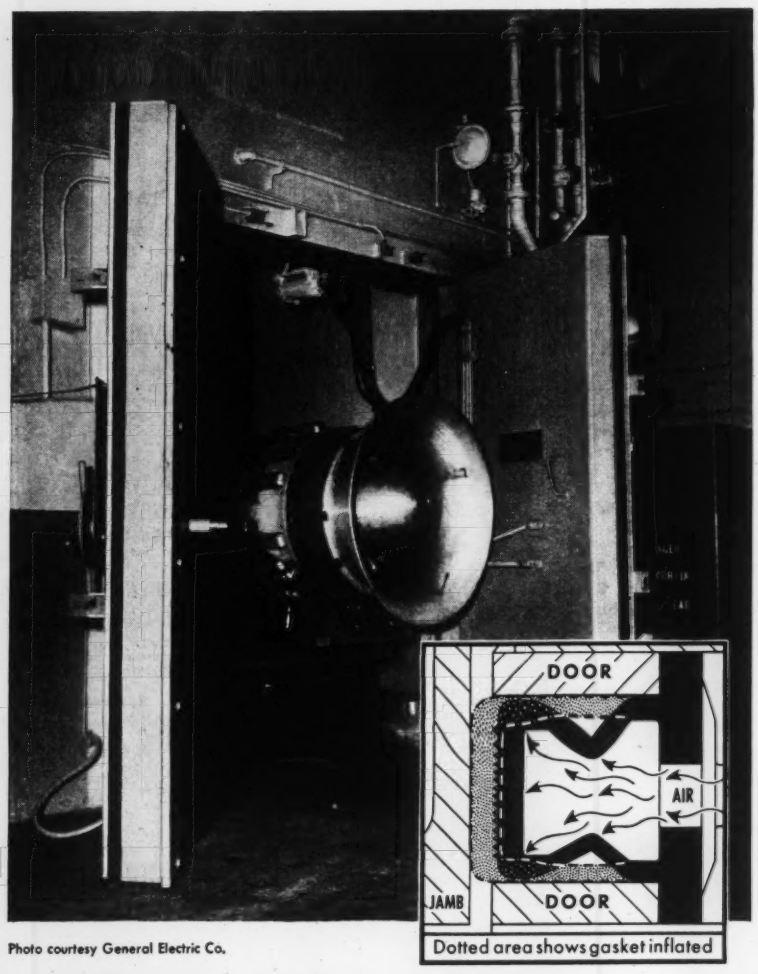

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Dotted area shows gasket inflated

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A guide to

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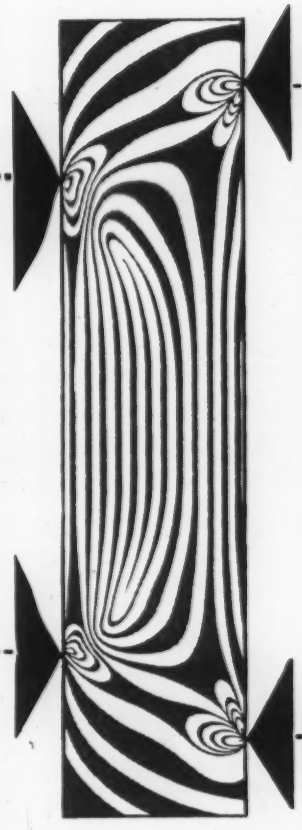

By J. B. HARTMAN
and R. E. Bonner
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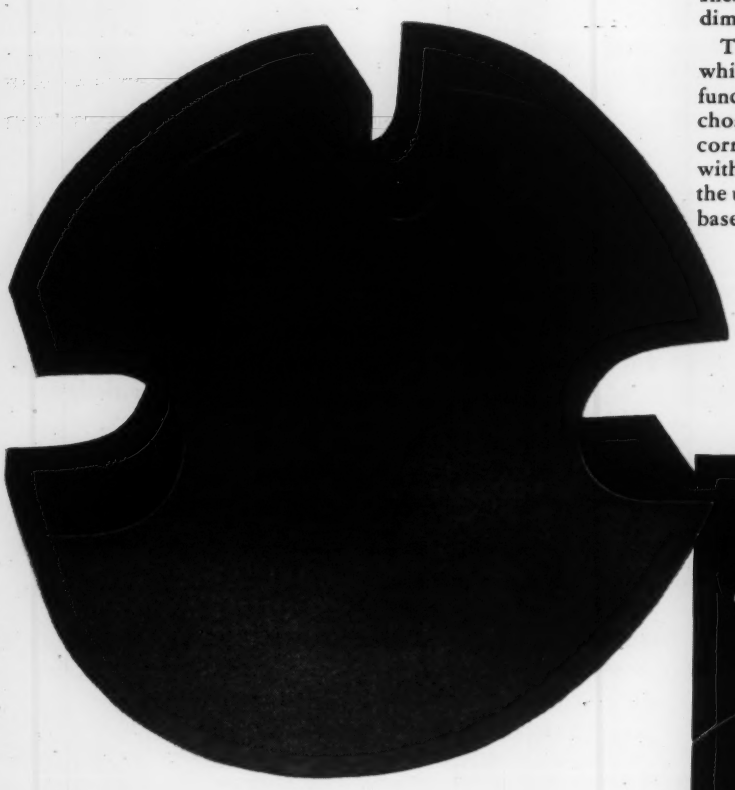

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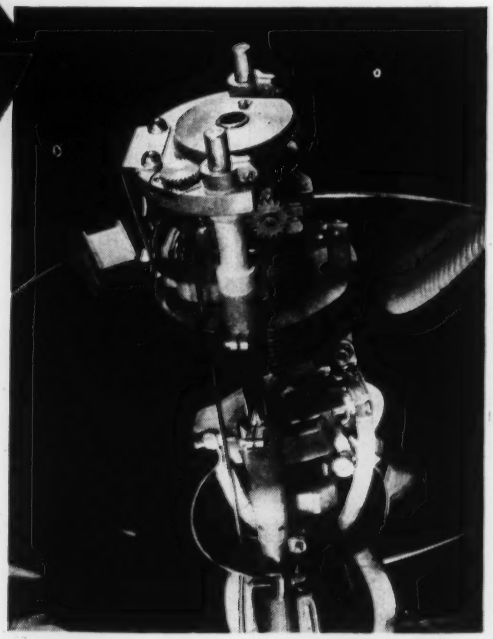
The unusual thing about this copper extruded shape is that it saves money in first cost as well as in machining time. The double economy amounts to over 25¢ per pound. The large illustration shows the shape as supplied in the form of a slug or pre-formed disc, 1 3/16" x 5". This begins as a long extrusion, from which Revere cuts the discs, and pickles them before shipping.

The customer is The Strong Electric Corp., Toledo 2, Ohio, which originally tried plate and bar, but found costs were too high. Revere Product Engineers, Methods and Production Departments collaborated with the company on the problem, and were able to develop the unusually heavy and economical shape. Strong reports a number of savings. One is that the shape is machined quickly and perfectly, with almost no rejects. This is due to the denseness and uniformity of the metal, a result of the high pressures exerted during extrusion. (Finishing operations include drilling bolt holes and cutting cooling fins.) As a secondary result of improved machining, the customer does not have to keep large inventories of metal to take care of spoilage, nor handle large quantities of scrap. Further, Revere supplies the discs in the correct thickness, eliminating a cutting-off operation for Strong. Incidentally, we are glad to supply shapes cut to dimensions, or in long lengths, as desired.

The completed part is an obturator-probe, which fulfills a control and heat dissipation function in a powerful searchlight. Copper was chosen for its ability to conduct heat and resist corrosion. Revere will be glad to collaborate with you in your search for economies through the use of extruded shapes in copper and copper-base alloys, and aluminum alloys.

Copper Extruded Shape, 1 3/16" x 5", as furnished.

Shape in place in a carbon arc searchlight mechanism.



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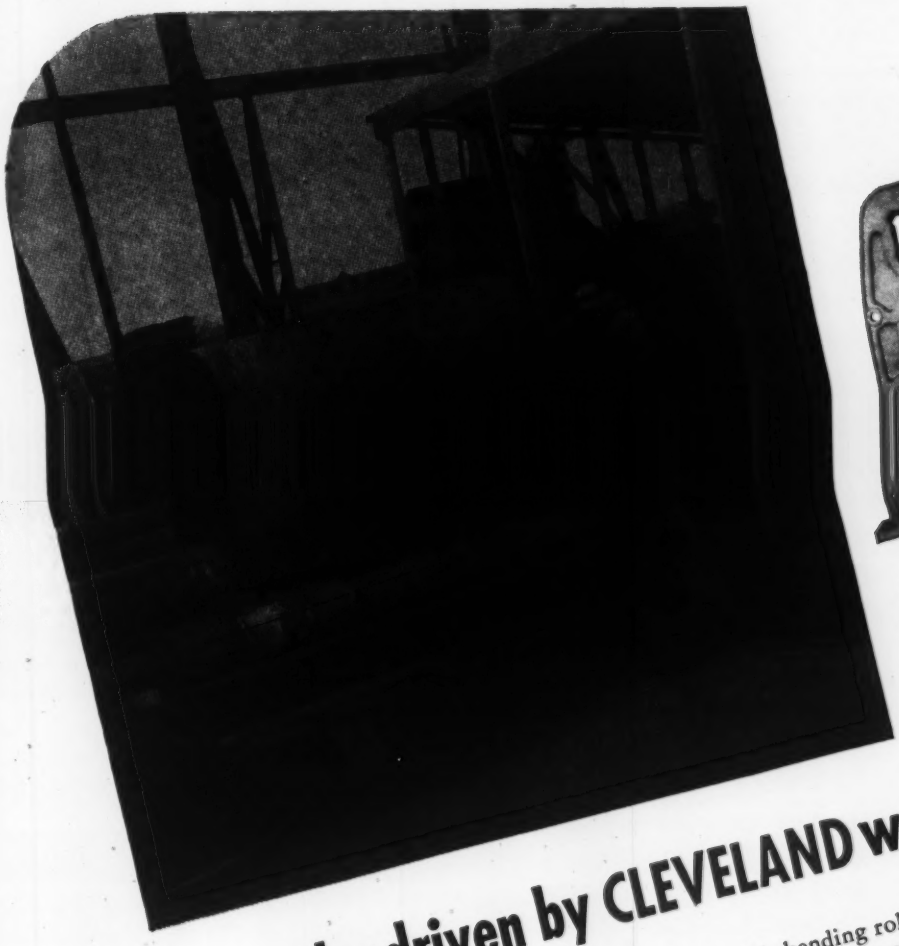

The Webb Corporation, Webb City, Mo., specializing in heavy duty bending rolls of the type shown at left, has long depended on Cleveland worm gear drives. Above is end frame of bending roll with worm gear set in place.

2½" plate bender driven by CLEVELAND worm gearing

HIDDEN from view, the heart of this bending roll is its Cleveland worm gear drive. Year after year, it transmits power smoothly from motor to the forming roll which curves heavy steel plate into perfect cylinders.

For many years Webb has listed Cleveland as standard equipment on its Model 16-L and other heavy duty machines. Webb's experience proves that worm gearing, as manufactured by Cleveland, withstands the extreme pressures of bending cold steel plates—as much as 2½" thick—and actually improves with use.

Whenever you need a drive that will keep its efficiency and stand up through years of severe service, specify a Cleveland Worm Gear Drive. Write for Catalog 400. The Cleveland Worm and Gear Company, 3287 East 80th Street, Cleveland 4, Ohio.

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